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19 ABSTRACT (Continue on reverse if necessary and identify by block number)

~~This volume~~ contains the interface control document (ICD) which defines the requirements related to the transfer of Global Positioning System (GPS) navigation data between the Operational, Status, and Capability (OPSCAP) Reporting and Management System (ORMS) and the Civil GPS Information Center (CGIC).

Volume III of this final report

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Global Positioning System (GPS)
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interface control document (ICD)
Civil GPS Service (CGS)
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OPSCAP Reporting and Management System (ORMS)

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# PREFACE

This is the final report for work conducted by Applied Research Laboratories, The University of Texas at Austin (ARL:UT), under Contract N00024-86-C-6134, Task 12, Project 18, under the technical instruction entitled "Incorporation of the Civilian Community in GPS Operation Capability Reporting System Study". This report is in four volumes. One of the primary efforts associated with this contract was the development of an interface between the U.S. Air Force and the civil community which will allow the civil community access to information regarding the navigation status of the Global Positioning System (GPS). This interface, or point of contact, operated by a civil organization and referred to as the Civil GPS Service (CGS), will serve as a source of information from the GPS Operation Control Segment (OCS) and other sources, and disseminate that information to the civil community. The Civil GPS Information Center (CGIC) will serve as the operational arm of the CGS by providing GPS status information to the civil community.

**Volume I. "Determination of the Requirements of the Civil GPS User Community," by Brent A. Renfro.**

Volume I summarizes all efforts performed by ARL:UT in meeting the specific tasks described in the contract. These include

(1) establishing a steering committee,
(2) determining needs of GPS civil users,
(3) determining data and data sources which are, or will be, available to the CGS,
(4) conducting a CGS user workshop, and
(5) developing a system design for data distribution.

**Volume II.** **"Appendices to Volume I," by Arnold J. Tucker, Brent A. Renfro, and Jeanne L. Williams.**

Volume II, a compendium of appendices, addresses the results of the above tasks in greater detail.

**Volume III.** **"Interface Control Document for the Civil GPS Service Interface to the OPSCAP Reporting and Management System," by Patrick R. Pastor.**

Volume III is the interface control document (ICD) defining the requirements related to the transfer of GPS navigation data between the Operational, Status, and Capability (OPSCAP) Reporting and Mar agement System (ORMS) and the CGS.

**Volume IV.** **"Synopsis of Civil GPS User Workshop (22 September 1987)," edited by Arnold J. Tucker.**

Volume IV is the synopsis of the GPS Civil User Workshop held on 22 September 1987 in Colorado Springs, Colorado. Included in this synopsis are transcripts of the oral presentations made during the General Session and also summaries from the various discussion groups which were chaired by members of the CGS Steering Committee.

For additional information regarding the CGS, direct queries to the following address.

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## 1.0 Scope

This interface control document (ICD) defines the requirements related to the transfer of Global Positioning System (GPS) navigation data between the Operational, Status, and Capability (OPSCAP) Reporting and Management System (ORMS), and the Civil GPS Information Center (CGIC).

Section 20, "GPS Navigation Data Structure of Data ID 2" from the ICD-GPS-200 is referenced in this document and is included as Appendix D.

Some items identified in this document are listed as to-be-determined (TBD). These items are required for the completion of an interface between ORMS and CGIC and will be determined by ORMS at a later date. This draft ICD is based on information available at this time and as the ORMS matures, revisions will have to be made to this document.

## 2.0 Applicable Documents

### 2.1 Government Documents

The following documents of the issue specified contribute to the definition of the interfaces between the ORMS and the CGIC, and form a part of this ICD to the extent specified herein.

Specifications

Federal

None

Military

None

Other Government Activity

None

Standards

Federal

None

Military

None

Other Publications

| | |
|---|---|
| ICD-GPS-200 | NAVSTAR GPS Space Segment/Navigation User Interfaces (NC) (U) |
| ICD-MCS-301 | OCS MCS CPCI Interfaces (SECRET) (U) |
| ICD-MCS-302A Appendix D | Alarm/Warning/Event Messages |
| CP-MCSEC-302A | Computer Program Specification for the Master Control Station Ephemeris/Clock Computer Program |
| | Civil GPS Service (CGS) Steering Committee Charter |
| | NAVSTAR GPS Security Classification Guide |
| | Requirements Document for the ORMS |

## 2.2 Non-Government Documents

The following documents of the issue specified contribute to the definition of the interfaces between the ORMS and the CGIC and form a part of this ICD to the extent specified herein.

Specifications

None

Other Publications

None

## 3.0 Civil GPS Service Overview

The interaction of the CGIC with the Civil GPS Service (CGS), the user community, and elements of the GPS control segment is shown in Fig. 1. The CGS is concerned with administration and operations while the role of the CGIC is distribution of information to the user community.

The function of the CGS is to serve as a source of information and a point of contact for civil users of GPS. The CGS also serves as a focal point for comments and questions from the civil community regarding GPS. In this case, 'civil' is defined to mean any organization which is not part of the Department of Defense (DoD) or the military segments of the North Atlantic Treaty Organization (NATO). DoD and NATO military organizations are served by the ORMS. From an operational standpoint, the CGS serves as a buffer between the USAF management and the civil GPS user community. The CGS also serves as a consolidation point for feedback from the civil user community to the administrators and operators of the GPS system.

The CGIC accepts information regarding GPS navigation status and capability from the ORMS and other sources and disseminates that information to the civil community via a number of channels.

The types of information provided by the CGIC include:

(1) planning information,
(2) current status information,
(3) archival (or historical) information, and
(4) responses to user questions.

This ICD specifically addresses the interface between the ORMS and the CGIC.

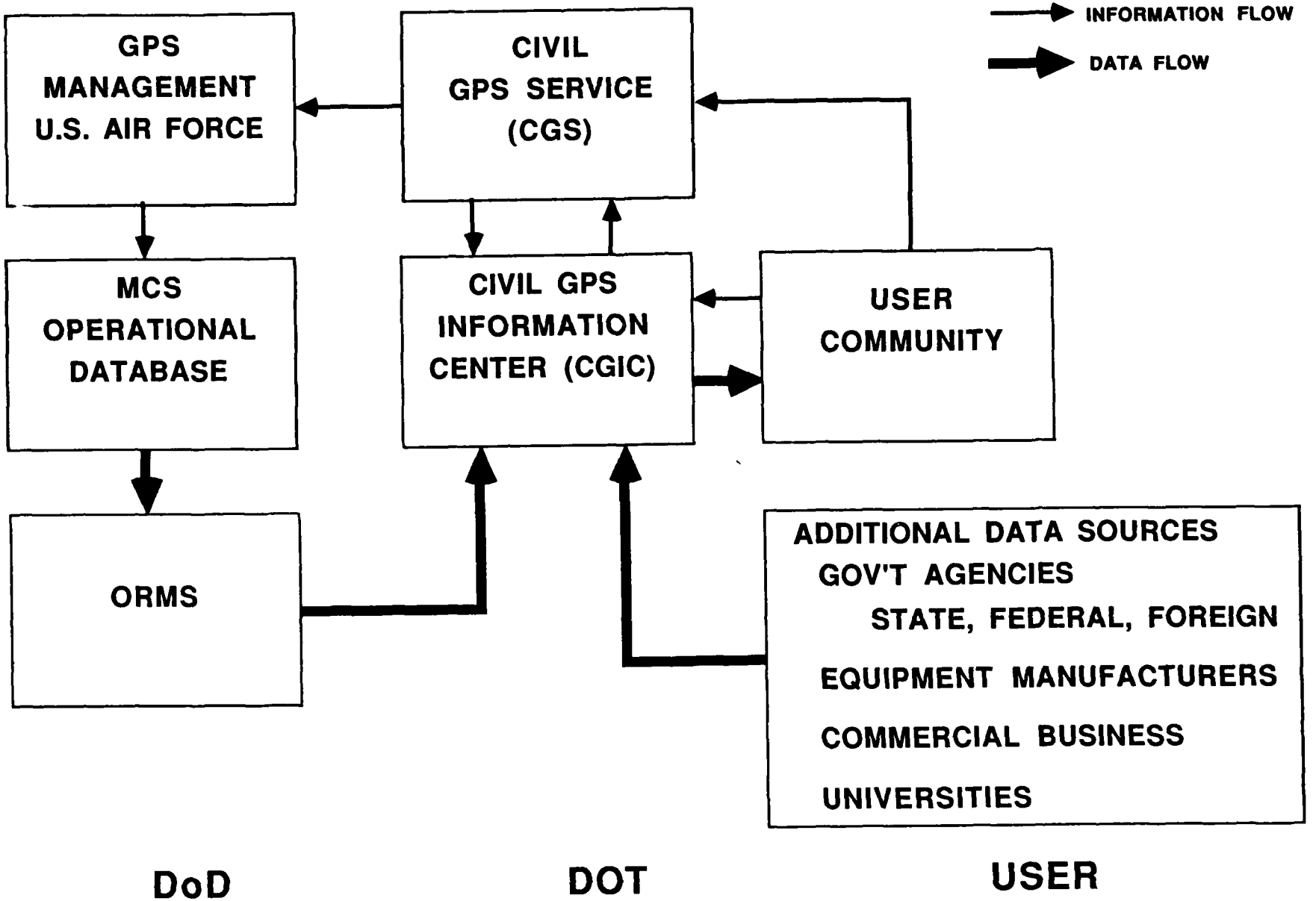


FIGURE 1
CGS ORGANIZATIONAL DIAGRAM



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## 4.0 CGS Data Quantities

### 4.1 Categorization of Data by Information Type

In general, it is convenient to categorize data elements transferred from the ORMS to the CGIC according to four information categories (see Table 4-1). The first two categories, Future Event and Unscheduled Event Advisories, both convey status and configuration information but the former is derived from scheduled or predictive information while the latter is concerned with unforeseen events related to system degradation or reconfiguration.

Future Event and Unscheduled Event Advisories are further subdivided into textual Notifications and System Status/Warning Message (S/S/W) information. S/S/Ws also include any associated classification codes and priorities. Notifications and S/S/Ws are normally transmitted whenever the line to the CGIC is free. In either case, as discussed in Section 4.2.1, both Future and Unscheduled Event Advisories are incorporated in the Short Delay transfer type.

The third information category, NAV messages, serves as an alternate source for SV NAV message information. In this category, data elements are generally transferred in both unpacked engineering units and in the broadcast message format. Like the NAV message itself, all data elements in the Intermediate NAV message category have any existing SA effects present. As discussed in Section 4.2.2, transmission to the CGIC is delayed at least (TBD) minutes after a data element has been incorporated into a NAV message transmission. The NAV message information is incorporated in the Intermediate Delay transfer category. The transmission of Intermediate Delay blocks occurs every hour on the hour, after their constituent data elements have sufficiently aged.

TABLE 4-1

INFORMATION CATEGORIES

| TITLE | DESCRIPTION | EXAMPLES |
|---|---|---|
| Future Event Advisories | Scheduled events textual notification and S/S/W information with codes and priorities | SV launches<br>GPS CS/SS capability and testing<br>SV orbit adjust<br>SV/MC clock status/ adjust/switch<br>GPS SV/MC time steering |
| Unscheduled Event Advisories | SVs/MC systems set unhealthy, performance degraded, or configuration changed due to unscheduled events. Include estimated recovery time and impact if applicable | Same as for Future Events Notifications |
| NAV Message | Alternate source of predictive quantities with SA effects present; available approximately TBD minutes after beginning of applicability | SV broadcast almanac,<br>SV broadcast ephemerides,<br>and remainder of NAV message except reserved pages |
| Postprocessed | Postprocessed values and MCS filter quantities with SA effects absent; available approximately TBD after beginning of applicability | SV monitored health<br>SV ORDs and ERD versus AOD<br>SV URAs versus AOD<br>SV/MCS/MC navigation status changes<br>Global SV upload schedule<br>SV ephemeris user range accuracy (URA) contribution<br>SV ephemeris<br>SV/MC clock URA contribution<br>SV/MC time steer parameters<br>SV/MC clock adjust parameters<br>SV clock calibration to universal coordinated time (UTC)<br>GPS-UTC phase and frequency offset |

The fourth and last information age category, postprocessed data, consists primarily of post-determined quantities as determined from operational diagnostic analysis of GPS data, and from post-fit values estimated by the MCS filter. In order to prohibit its realtime use, the data are not transmitted to the CGIC for approximately TBD days after their time tags of applicability. In general, SA effects are not present in these data elements. As discussed in Section 4.2.3, postprocessed data is incorporated into the Long Delay transfer category. Long Delay information is stored, internal to the ORMS, and transmitted, after sufficient aging, during periods when the line to the CGIC is not otherwise occupied. Table 4-2 shows the mapping of data information into data transfer types.

The six information types that constitute the information transmitted to the CGIC are discussed in detail in Sections 4.1.1 through 4.1.6.

### 4.1.1 Future Event Advisories

Future Event Advisories consist of two types of transfer blocks: Notifications and System Status/Warning Message information.

Notifications are human generated, whereas S/S/Ws are system initiated. The sub-grouping of Advisories is diagrammed below.

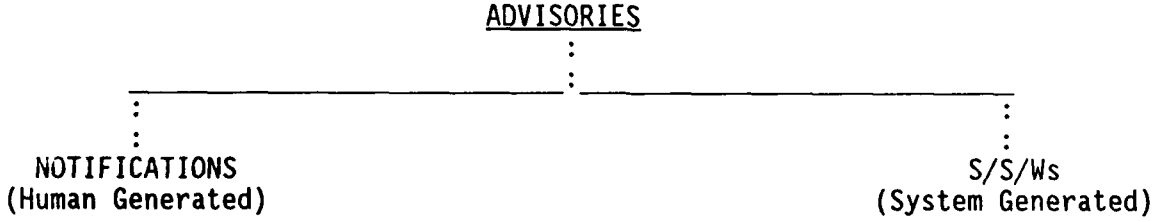

TABLE 4-2

DATA INFORMATION BY DATA
TRANSFER TYPES

| Categories of Data Information | Categories of Data Transfer |
|---|---|
| Future Event Advisories | Short Delay Transfer |
| Unscheduled Event Advisories | |
| NAV Messages | Intermediate Delay Transfer |
| Postprocessed | Long Delay Transfer |

Table 4-3, Future and Unscheduled Event Advisories, lists data quantities that are of interest to the CGS.

#### 4.1.1.1 Notifications

##### 4.1.1.1.1 Notification Generator

An outline for Notifications is presented in Table 10-1 of Section 10.1. This outline has several different entries, not all of which are applicable to all Notifications produced. To allow for some measure of sorting and search capability, several fields contain indexing information, for instance notice advisory number, and affected SV(s)/MS(s). To facilitate its use by a database program, indexed fields (those not labeled in the table by a "*") have a fixed or predefined format. Due to this format, creation of Notifications is accomplished via program entry which prompts for fields, and where appropriate, gives choices, defaults, and ensures format conventions. In addition, this Notification Generator checks for inconsistency between fields.

##### 4.1.1.1.2 Time Relevance

The "time relevance" field in the Notifications format (see Table 10-1) provides a measure for how relevant in time a Notification is to users. A user uses time relevance, in conjunction with other keys, to search for timely information that may impact their future, immediate, present, recently completed, or past GPS operations. If sufficiently important, mention of the Notification is included in the CGIC log-on message. Another index field, namely reference dates and times, provides another method of locating these data in time.

TABLE 4-3

EXAMPLES OF FUTURE EVENT ADVISORIES
AND UNSCHEDULED EVENT ADVISORIES

| DATA | DESCRIPTION | REFRESH RATE |
|---|---|---|
| SV Launches | Launch announcement, approximate date | Announcement(s)/launch |
| GPS CS/SS Capability and Testing | Occurrence of S/S/Ws, classification and priorities, include warning and description of non-classified testing, ORs, system malfunctions, etc., affecting the control or space segment | Announcement(s)/S/S/W |
| SV Orbit Adjust | Orbit perturbations including maneuvers, momentum dumps, eclipse, etc., with dates and scheduled/predictive parameters | Each occurrence |
| SV/MC Clock Status/ Adjust/Switch | Change in SV or MC clock status, and occurrence of adjust or switch in oscillator per SV or MC with event description and associated time tags | Each occurrence |
| GPS SV/MC Time Steer | Announcement of scheduled/predictive steering parameters of broadcast accuracy | Each occurrence |

Figure 2 assigns time relevance by defining conventions for time windows. Its structure gives the highest relevance to current information which impacts user performance. Lowest relevance is given to the least current information that does not impact user performance.

Whether a described condition may affect user performance is determined by the author of the Notification and is based on both the severity of the condition, any actions to be taken, and experience based on previous occurrences of similar conditions/actions. (For example, user processing is said to be affected when events occur which degrade a user's GPS tracking capability, i.e., an SV change from healthy to unhealthy or vice versa, and/or probably impacts performance on the order of hundreds of meters or more, i.e., a change in SV frequency standards from cesium to quartz oscillator.)

In summary, the time relevance field of event Notifications are determined by the immediacy of the data and by the effect of the event on user performance.

#### 4.1.1.2 System Status/Warning Messages

Transfer of certain MCS/ORMs generated S/S/W messages to the CGIC is supported. This facility makes use of the occurrence of a selected subset of Alarm/Warning/Event (A/W/E) messages from the MCS and the ORMS systems in order to: (1) provide an efficient automated means of recording GPS system performance, and (2) lessen the requirement for human generated textual Notifications discussed previously in Section 4.1.1.1.

The A/W/E information transmitted is not to compromise the security of the GPS system nor delve into the operational aspects of either the MCS or the ORMS. Only those A/W/Es cleared by a security mask are

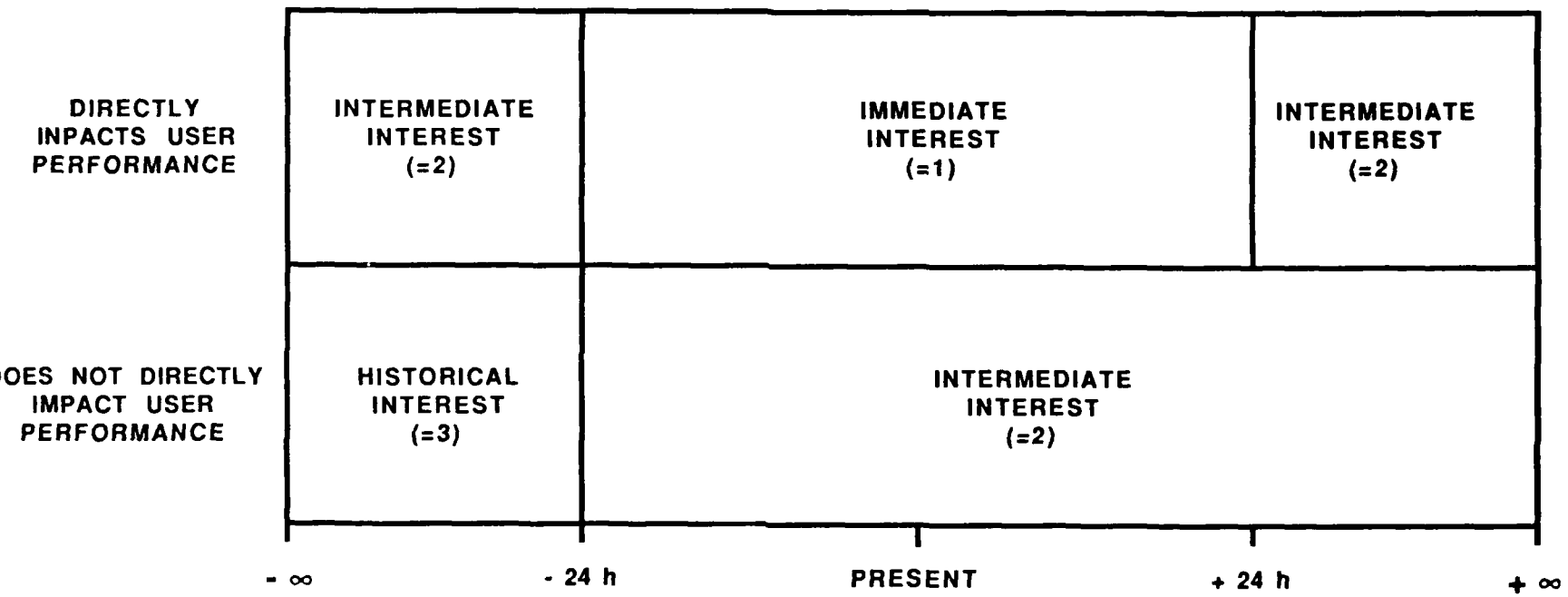


**FIGURE 2**
**TIME RELEVANCE**



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passed to the CGIC. Another mask is applied to determine if a message is transmitted as Short Delay or, because of security considerations, in the Long Delay data age category (under the Long Delay S/S/W messages transfer block). All values in the Short Delay Advisory S/S/Ws are of only scheduled or predictive accuracies, i.e., no post-fit values.

The specific format of S/S/W transfer blocks are contained in Section 10.2. The list of A/W/Es transmitted to the CGIC, along with their designations as Future and Unscheduled Event Advisories or Postprocessed Information, will be defined in a separate document. This list provides for the fact that the MCS A/W/E file can change over time.

### 4.1.2 Unscheduled Event Advisories

Unscheduled Event Advisories, like the previously discussed Future Event Advisories (Section 4.1.1) are similarly composed of both textual, human generated Notifications and system generated S/S/Ws. The same transfer block formats, as described in Sections 10.1 and 10.2, are used for both Future and Unscheduled Event Advisories. Whereas Future Event Advisories apply to events scheduled to occur in the future, near or far, Unscheduled Event Advisories apply to GPS status events that have occurred due to unforeseen consequences.

Currently, there exists no foolproof method of distinguishing between the two. The delineation is not intended as a method of tracking the GPS system's scheduling performance, but rather to aid the user in delineating between those messages that apply to future events and those that may impact data already taken or operations in progress.

### 4.1.3 NAV Message Information

The NAV Message category serves as an alternate source for obtaining subsets of the Navigation Message information broadcast from all SVs. Navigation message data is transferred in both unpacked engineering units, and in the broadcast navigation message format. Transmission to the CGIC is delayed approximately TBD minutes after a broadcast's contents have been incorporated in a NAV message data block. When a data block's parameters are transmitted by several SVs (see Section 4.1.3.3), CGIC transmission delay criteria are determined by the last SV to begin broadcasting.

Like the NAV Message itself, all data elements in the NAV Message category will have any existing SA effects present. Data elements transferred in unpacked engineering units do not contain greater resolution or accuracy than that available in the corresponding NAV message elements.

Data from reserved element pages of the Navigation message are not transferred to the CGS. Reserved element portions are pages 1, 6, 11, 12, 16, and 19-24 of subframe 4.

The specific formats of the NAV message data, incorporated into Intermediate Delay transfer blocks, are contained in Section 20, Appendix II.

Table 4-4 lists data quantities, which are of interest to the CGS, that are included as NAV Message blocks.

#### 4.1.3.1 Alternate Source of Broadcast Data

The primary function of the NAV Message information is to provide the user an alternate source of navigation message broadcast data. In

TABLE 4-4

NAV MESSAGE INFORMATION

| DATA | DESCRIPTION | REFRESH RATE |
|---|---|---|
| SV Broadcast Almanac | Subframe 5, pages 1-24 and subframe 4, pages 2-5, 7-10; plus WNA, telemetry validity flag, and upload times: beginning time tag of applicability | Each almanac set |
| SV Broadcast Ephemerides | Subframe 1, 2, and 3 as broadcast per SV, telemetry validity flag, and upload times: beginning time tag of applicability | Each broadcast ephemeris |
| Remainder of NAV (excluding reserved pages) | Balance of NAV message as broadcast per SV telemetry validity flag, and upload times: beginning time tag of applicability | Each new NAV message page |

effect, the NAV message information functions as a virtual receiver of all SV broadcast messages. This alternate source information is used to establish a NAV message database on the CGS that provides users the capability of verifying, shortly after data capture, receiver hardware, software, and processing algorithms. The database also provides a means of determining the NAV message contents in the event of receiver errors, and/or help in simulating conditions that occurred during that error. Most commonly, it is used in conjunction with postprocessing of GPS data, especially when portions of the NAV message are not available in the receiver's local data.

In order to be as useful as possible, the NAV Message data blocks are constructed to contain as complete a set of NAV messages, over both time and breadth of broadcast information, as is possible. For this reason, all NAV broadcast message subframes and pages, except for reserved pages, are included.

As discussed in Section 4.2.2, the NAV Message information is included in the Intermediate Delay data transmission so that broadcast data may be made available to the CGS users as quickly as possible.

Since many SVs normally broadcast the same NAV message subset, e.g., an almanac, particular Intermediate Delay blocks are arranged to correspond to individual sets of NAV message parameters. This construct minimizes the number of transfer blocks containing the NAV Message information. For these blocks, correspondence to the transmitting SVs is indicated by a matrix of SV identifiers and corresponding times of transmission.

#### 4.1.3.2 Verified versus Uploaded NAV Messages

Instead of presenting actual MCS monitored data, Intermediate Delay blocks are constructed from data contained in the SV uploads. The

uploaded message only contains information for words 3-10 of NAV Message page or subframe. By convention, the simulated contents of words 1 and 2 contain TLM and HOW words that describe the first SV to transmit a data block's NAV information. Specifically, the packed "TOW-count message" corresponds to the beginning of broadcast for the first transmitting SV. The exception to this convention is that the flags for Roll Momentum Dump/Alert and Synchronization/A-S are set to zero in a NAV block's broadcast message contents.

Broadcast errors detected by the OCS's navigation verification testing, i.e., the comparison of monitored data with the predictive data from the upload, are included in the Navigation Data Error summary block described in Section 30.1.10.

4.1.3.3 Synchronization Considerations

The matrix of transmitting SVs/beginning transmission times, which apply to a particular Intermediate Delay block's data parameters (see Section 4.1.3.1) are, in general, ordered neither according to SV numbers or to upload times. The only constraints imposed are:

(1) during a block's building cycle, SV PRNs are ordered in the same sequence as the beginning broadcast times (see Section 4.2),

(2) the unpacked NAV message's words 1 and 2 correspond to the first transmitting SV (see Section 4.1.3.2), and

(3) uploaded NAV data blocks are transmitted to the CGIC even if verification errors occur during part or all of its corresponding transmission time (see Section 4.1.3.2).

Please note that the above synchronization constraints do not preclude the occurrence of multiple Intermediate Delay blocks containing the same set of data parameters but corresponding to different sets of

transmitting SVs. However, in order to conserve system resources, ORMS system parameters are tuned to minimize this occurrence (see Sections 4.2 and 5.3.3).

### 4.1.4 Performance Information

Table 4-5 lists data quantities that are included in Performance Information blocks. The formats of the Performance blocks are contained in Section 30.1

The data transfer requirements of Performance Information are found in Section 4.2.3; incorporation in transmission to the CGIC is described in Sections 5.1 and 5.1.2.

### 4.1.5 SV Ephemeris Information

Table 4-6 lists data quantities that are included in SV Ephemeris Information blocks. The formats of the Ephemeris blocks are contained in Section 30.2.

The data transfer requirements of Ephemeris Information are found in Section 4.2.3; incorporation in transmission to the CGIC is described in Sections 5.1 and 5.1.2.

### 4.1.6 GPS Clock Information

Table 4-7 lists the data quantities that are included in GPS Clock Information blocks. The formats of the Clock Information blocks are contained in Section 30.3.

The data transfer requirements of GPS Clock Information are found in Section 4.2.3; incorporation in transmission to the CGIC is described in Sections 5.1 and 5.1.2.

TABLE 4-5

PERFORMANCE INFORMATION

| DATA | DESCRIPTION | REFRESH RATE |
|---|---|---|
| SV Monitored Health | OCS navigation oriented manual assessments and SV alerts; and summary of NAV message data that did not compare with upload | Each change |
| SV ORDs and ERDs versus AOD | ORDs from each MS; PRDs from up to 32 geographic locations, with SA effects present, associated time tag, with SV ephemeris and SV/MC clock contributions | Each UTC day |
| SV URAs versus AOD | Filter's range variance estimate as a function of time, per SV with associated time tag, also SV ephemeris and clock contribution | Every TBD filter update |
| Long Delay S/S/W Messages | S/S/Ws and Notifications, post-determined or not included in future event or unscheduled advisories; includes: steering, testing, ORs, system and malfunction, etc., textual description of each S/S/W, its priority, classification, and time tag | Each S/S/W |
| Global SV Transmit and Upload Schedule | Time for SV broadcast of ephemeris, almanacs, clock, ionospheric, etc., upload times; beginning time tag and ending time tag of broadcast | Each UTC day |

TABLE 4-6

SV EPHEMERIS STATE INFORMATION

| DATA | DESCRIPTION | REFRESH RATE |
|---|---|---|
| Kalman Estimated SV Ephemeris | MCS filter's estimated ephemeris positions, velocities, and clock states; beginning and ending times of applicability and fit interval | Every TBD Kalman update |

TABLE 4-7

GPS CLOCK INFORMATION

| DATA | DESCRIPTION | REFRESH RATE |
|---|---|---|
| SV/MC Time Steer Parameters | SV and MC steering parameters | Each occurrence |
| SV/MS Clock Adjust Parameters | SV and MC clock adjust parameters | Each occurrence |
| SV Clock Calibration to UTC | Post-determined quantity in the units of subframe 4, page 18 from filter solution per SV, with parameters and associated time tags | Every TBD filter update |
| GPS-UTC Coordination | Phase and frequency offset parameters of each GPS master clock and Allan variance versus time | Every TBD filter update |

## 4.2 Categories of Data Transfer Requirements

The data transferred from the ORMS to the CGIC are divided into three categories describing the timeliness of the transfer of information. The three categories are: Short Delay, Intermediate Delay, and Long Delay. As will be discussed in Section 5.1, the Short Delay and Intermediate Delay categories are transmitted via the aperiodic data transfer mode. The higher volumes of the Long Delay category are sent to the CGIC using the periodic transmission mode.

Each data block has an associated "latency period" which is the time a block is held, internal to the ORMS, during its building process. The purpose of latency periods is to minimize the number and repetition of those blocks which contain information from more than one SV or solution interval.

After its latency period has expired, a block may have to be delayed an additional time interval before it is released for potential transmission to the CGIC. The lower bound on this minimum delay interval is referred to as the transfer delay. The transfer delay is defined as that time interval, after a block's latest time tag of applicability, that the contained information must age before it is released for transfer to the CGIC. Transfer delay floors are instituted in order to prohibit immediate use of sensitive information. In actual practice, transfer delays will generally be exceeded due to delays introduced by communication backlogs, or the periodic nature of transmission modes.

Figure 3 illustrates the time relation of a hypothetical data block's latency interval, transfer delay, and transmission time. A data block's update frequency is the sampling rate for information gathering and, if required, the generation of a new block.

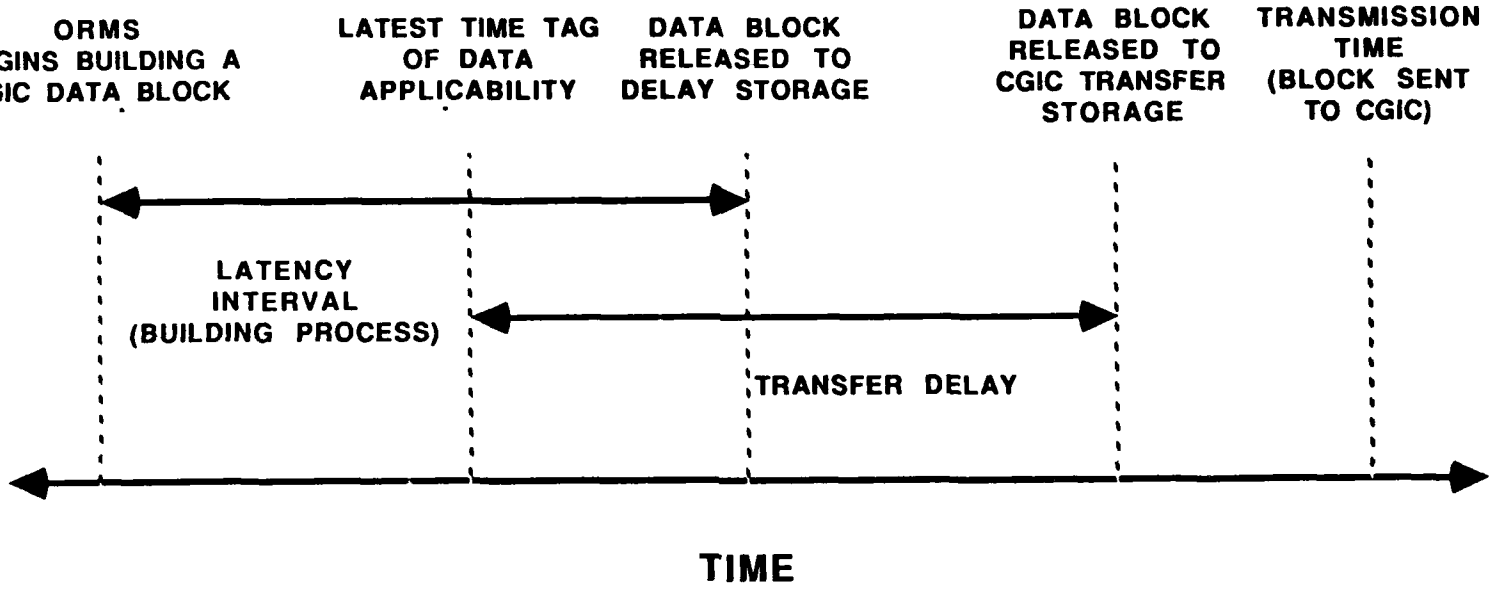


**FIGURE 3**
**FUNCTIONAL ILLUSTRATION OF**
**LATENCY INTERVAL, TRANSFER DELAY, AND TRANSMISSION TIME**
**FOR A HYPOTHETICAL DATA BLOCK**



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As applicable, latency periods, transfer delays, and update frequencies will be presented as each data transfer type is discussed in Sections 4.2.1 through 4.2.3.

Table 4-8 shows the mapping of data information into the data transfer types.

### 4.2.1 Short Delay Information

The Short Delay transferred information includes both future and unscheduled event advisories. The advisories are discussed in Sections 4.1.1 and 4.1.2; their format of data transfer is contained in Section 10.0. See Section 4.1.1.2 for a more complete discussion of A/W/Es.

Data blocks of the Short Delay transfer category have no latency periods, the transfer delay in TBD minutes. Individual Short Delay data blocks are generated for each occurrence of Notifications, or S/S/W messages from a preselected set.

### 4.2.2 Intermediate Delay Information

The Intermediate Delay information category transfers blocks containing NAV message information, as discussed under Section 4.1.3. The format of Intermediate Delay transferred data is given in Section 20.

All data blocks of the Intermediate Delay transfer category have the same transfer delay of TBD minutes. Latency periods, ranging from 90 minutes for Broadcast Ephemeris Blocks to one day for Almanac Blocks, are governed by a balance of: the time required to upload a block's parameter set into all SVs that will eventually broadcast it, the time needed to monitor a broadcast, and blocks released frequently enough to still contain timely information.

TABLE 4-8

MAPPING OF DATA INFORMATION
INTO THE DATA TRANSFER TYPES

| Categories of Data Information: | Categories of Data Transfer: |
|---|---|
| Future Event Advisories<br>Notifications<br>S/S/W Messages<br><br>Unscheduled Event Advisories<br>Notifications<br>S/S/W Messages | Short Delay Transfer |
| NAV Messages | Intermediate Delay Transfer |
| Postprocessed<br>Performance Information<br>Ephemeris Information<br>Clock Information | Long Delay Transfer |

The frequency of update for Intermediate Delay is governed by the frequency with which new parameter sets are employed in the global broadcast message set. If the parameter set is changed frequently in the NAV message, then the corresponding Intermediate Delay block will be updated frequently. As discussed in Section 4.1.3.1, each Intermediate Delay data block corresponds to only one parameter set; however, because of the latency periods, more than one data block may contain the same parameter set--though broadcast by different SVs.

### 4.2.3 Long Delay Information

The Long Delay information category transfers performance, ephemeris, and clock quantities as discussed under Sections 4.1.4 to 4.1.6. The format of Long Delay transferred data is given in Section 30.

All data blocks of the Long Delay transfer category have the same transfer delay of TBD days. Latency periods range from 0 minutes for Long Delay S/S/W message blocks to 26 hours for global SV transmit and upload schedule blocks. In a manner similar to the Intermediate Delay Information Category, these varying latency periods are chosen to balance data block content, size, and communication requirements.

The frequency of update for Long Delay information is governed by balancing the tradeoffs between data resolution and available communication capacity between the ORMS and the CGIC system.

## 5.0 Communications between the ORMS and the CGIC Systems

This section describes the functional requirements of data and information transfer between the ORMS and the CGIC systems.

## 5.1 Regular Modes of Data Transmission to the CGIC

To facilitate the timely transfer of information discussed in the previous sections from the ORMS to the CGIC, two regular modes of data transmission are employed. Two modes are employed so that smaller quantities of time relevant information may be transmitted to the CGIC as they are made available (aperiodic transfer mode), while the larger quantities of long delay information are transmitted to the CGIC at regular time intervals (periodic transfer mode).

Table 5-1 shows the mapping of the three categories of data transfer requirements into the two regular modes of data transmission.

### 5.1.1 Aperiodic Transmission Mode

The aperiodic transmission mode is capable of sending data blocks from the ORMS that have recently become available for transmission to the CGIC system. This mode provides timely transmission of the small to intermediate volumes of Short Delay and Intermediate Delay transfer information (see paragraphs 4.2.1 and 4.2.2).

The prioritization scheme for transmitting information functionally residing in the aperiodic transmission mode storage buffer is first in first out (FIFO); that is, oldest available information is transmitted first.

### 5.1.2 Periodic Transmission Mode

The periodic transmission mode is capable of providing regularly scheduled high capacity transfer of information from the ORMS to the CGIC system. This mode serves to transmit, via a non-continuous communication link, the large volume of Long Delay information (see Section 4.2.3).

TABLE 5-1

DATA MAPPING OF TRANSFER REQUIREMENTS
INTO REGULAR MODES OF DATA TRANSMISSION

| Categories of Data Transfer Requirements | Categories of Regular Modes of Data Transmission |
|---|---|
| Short Delay Transfer | Aperiodic Transmission Mode |
| Intermediate Delay Transfer | |
| Long Delay Transfer | Periodic Transmission Mode |

The prioritization scheme for transferring information using the periodic transfer mode is FIFO. The scheduling of the periodic transmission times is discussed in Section 5.3.2.

## 5.2 Retransfer of Information to the CGIC

This section discusses methods of transferring information previously prepared by the ORMS system, but later requiring retransfer for one of several reasons. The reasons for retransfer include

(1) superseding information generated by the ORMS (see Section 5.2.1),
(2) testing in the ORMS system (see Section 5.2.2), and
(3) retrieval of ORMS archived information (see Section 5.2.3).

### 5.2.1 Superseding Information from the ORMS

To allow for the identification of superseding information that originates from the ORMS, all data transfer blocks are stamped with a version number and a time tag indicating release for transmission to the CGIC. The superseding data blocks are transferred to the CGIC using the same transmission mode as was used in transmitting the original data.

Data blocks whose information is tied to MCS filter update intervals which have been reprocessed are examples of superseding information blocks. No overwrite or automatic retransmit of the superseded information is performed, even if earlier versions of the data blocks are still contained in the transmission buffer.

### 5.2.2 Testing in the Systems

To support testing in either the CGIC or ORMS systems, the option to retransmit information previously transmitted by regular transmission

is available. This mode of retransmission is referred to as the capture mode.

This special mode may not be run for an indefinite time; its duration is determined by the requirements of the ORMS system.

Initialization of the capture mode and the request to start retransmission of recent data captured by this mode is not part of the CGIC/ORMS communication protocol, but is handled by communication between the managers of the two systems. The retransmitted data blocks are transferred to the CGIC using the same transmission mode as was used in transmitting the original data.

### 5.2.3 Retrieval of ORMS Archived Information

To support recovery from errors occurring in either the CGIC or ORMS systems, the option to retrieve information from the ORMS archived tapes is available. This mode of recovery applies only to that information previously formatted for regular transmission by the ORMS to the CGIC system. This option does not levy any additional requirements as to the duration of archive support in the ORMS system.

The requested retrieved data are transmitted to the CGIC via the periodic transmission mode. Retrieved archive data blocks are identified by the setting of the archive field of the data blocks.

CGS requests to retrieve ORMS archived information is not part of the CGIC/ORMS communication protocol, but is handled by communication between the managers of the two systems.

## 5.3 CGIC Communication to the ORMS

This section describes communication originating from the CGIC that is directed to the ORMS. In scope this section encompasses both information that is passed by communication between the managers of the two systems and that which is part of the CGIC communication protocol.

The types of communication from the CGIC to the ORMS include
(1) transmission of CGIC status information (Section 5.3.1),
(2) scheduling information (Section 5.3.2),
(3) tuning information (Section 5.3.3),
(4) requests for data retransfer (Section 5.3.4), and
(5) request for modification of regular transmission contents (Section 5.3.5).

### 5.3.1 Transmission of CGIC Status Information

The communication protocol employed supports the transmission of CGIC status information to the ORMS system. This status information is used to indicate if the CGIC system is ready to accept data. If flagged not ready, the ORMS locally stores these data intended for transmission to the CGIC.

### 5.3.2 Scheduling Information

Since the periodic transfer mode, discussed in Section 5.1.2, occurs in accord with a prearranged schedule, there exists the option that the CGIC can request changes to the schedule of transmitting periodic data packets. Examples of other activities that need to be scheduled are workarounds, scheduled maintenance, or support for testing on either of the systems. The communication of scheduling information is not part of the CGIC/ORMS communication protocol, but is handled by communication between the managers of the two systems.

### 5.3.3 Tuning Information

At the request of the Civil system, certain transmission tuning information is adjusted by ORMS to optimize and adjust the communication link between the CGIC and the ORMS under varying data loads and evolving CGIC/ORMS operating procedures. Requested changes in tuning information are not part of the CGIC/ORMS communication protocol, but are handled by communication between the managers of the two systems.

### 5.3.4 Requests for Data Retransfer to the CGIC

The requests for data retransfer, as specified in Section 5.2, are not part of the CGIC/ORMS communication protocol, but are handled by communication between the managers of the two systems.

### 5.3.5 Request for Modification of Regular Transmission Contents

The option to request the modification of regular transmission contents exists to allow for future growth and changes in both the CGIC and ORMS systems, as well as in the MCS itself.

Requests for modifications must be approved first by the directors of the CGIC and next by the ORMS. The format of the modifications to the regular transmission contents must be specified in detail. In addition an update of this ICD, incorporating all changes required to support the requested modifications, must be submitted.

As a special case, see the information in Section 10.2 regarding amendments to the subset of S/S/Ws passed to the CGIC system.

The actual request for modification of regular transmission is not part of the CGIC/ORMS communication protocol, but is handled by communication between the managers of the two systems.

## 6.0 Common Data Element Definitions

The following common definitions are used within this document to define a number of standardized satellite, time, and data set data elements. Each defined item contains a description of the item including its form, precision, and derivation.

### 6.1 SV Identification

Satellites are identified by the same convention as employed by the MCS, namely by a unique SV reference number which is an integer in the range 0-255. The SV reference number is related to the PRN code by the same mapping as that employed by the MCS. Table 6-1 presents a list of the satellite vehicle identifiers.

PRN code is a two-character (numeric) designation that defines the segment of the PRN code sequence used by a specific SV. This PRN code is used by monitor stations and user sets to acquire the L-band signal broadcast by the SV. There are 37 segments currently defined of which 32 are assigned as possible SV codes.

### 6.2 Time Tag Representation

Table 6-2 summarizes the convention for time tags. All time tags associated with data transferred to the CGIC are presented in the GPS week number in the full 10-bit value; the seconds of week is derived from the Z-count value and therefore has a precision of 1.5 sec.

TABLE 6-1
SATELLITE VEHICLE IDENTIFIERS

| SV IDENTIFIER | UNIT/FORMAT | VALUE/RANGE |
|---|---|---|
| SV Reference Number | Integer | 0-255 |
| PRN Code | Integer | 0-37 |

TABLE 6-2
COMMON DATA ELEMENT SUMMARY

| ITEM | UNIT/FORMAT | VALUE/RANGE | PRECISION |
|---|---|---|---|
| Time Tag | | | |
| GPS Week Number | Weeks/Integer | 0-1023 | 1 |
| Seconds of Week | Seconds of GPS Week/Real | 0-604798.5 | 1.5 |

# 10.0 APPENDIX A
# SHORT DELAY TRANSFER BLOCKS

## 10.1 Notification Block Format

The Notification file contains information relating to GPS, MCS, and the ORMS status, as discussed in Section 4.1.1.1.

### 10.1.1 Contents Definition

The contents of this file are defined in Table 10-1 and described in Table 10-2 (TBD). A new file block is associated with each Notification. Each Notification describes only one condition, or a set of closely related conditions (related by causality, not by time).

### 10.1.2 Usage

This file contains information pertaining to both Future and Unscheduled Event Advisories.

### 10.1.3 Special Requirements

Under certain conditions, notifications describing "conditions" or "actions" originating in the user segment (e.g., an error encountered in a certain class of GPS receivers, solution software, etc.) are generated internal to the CGIC.

TABLE 10-1

NOTIFICATION FILE DEFINITIONS

| ITEM | DESCRIPTION |
|---|---|
| Notification Type | Type of notification<br>1 = future event notification<br>2 = unscheduled event notification |
| Archive Flag | Flag indicating block has been retrieved from ORMS archive<br>0 = block from regular transmission<br>1 = block retrieved from archive |
| AIG Routing Code | Automated information group routing code |
| Reference Dates and Times | Beginning and ending time of condition defined in notification |
| System Entry Date and Time | Time notice input into system (should be assigned by system) |
| Notice Advisory Number | Formatted yy-kkk, where yy is ast 2 digits of year and kkk is notice advisory sequence number |
| Version/Supersedes | Notice advisory number of previous notification that current notification either augments or supersedes, exact nature of update should be given under condition or action sections (when applicable) |
| Time Relevance | Urgency of message (see Section 4.1.1.1.2 and Fig. 2)<br>1 = of immediate usefulness<br>2 = of intermediate interest<br>3 = of historical interest |
| Subject Header | One line summary of the subject of the notification |
| A/W/E Message Category | Originating Alarm/Warning/Event message category number which precipitated the generation of this notification; else, a related A/W/E category number which is descriptive of or closely related to this notification's condition (when applicable) |

| ITEM | DESCRIPTION |
|---|---|
| Effected Subsystem | GPS subsystem from which "condition", described below, originated<br>1 = GPS control segment<br>2 = GPS space segment<br>3 = GPS user segment<br>4 = Other |
| Effected SV(s)/MS(s) | SVs, MSs impacted by notification (when applicable) |
| Condition* | Text describing condition, in the GPS system, that existed, is existing, or may exist, -- only one condition/action pair described per notification |
| Action* | Text describing action, in response to above condition, that was taken, is being taken, or to be taken (when applicable) |
| Estimated Recovery Time* | Estimation of duration of condition/action's effect (when applicable) |
| Estimated Impact* | Estimation of impact -- both scope and effect -- of condition/actions (when applicable) |
| Recommended User Action* | Recommended action user should or may take in response to condition/actions (when applicable) |
| Reference/Background Notes* | Reference or background notes relating to condition/actions that serves to give definitions, further explanation, or is impacted/amended by the contents of this notification (when applicable) |
| Originator | Origin of notification (organizational/title) |
| POC | Point of contact within MCS or ORMS that authorized personnel may contact if further questions arise |

* Indicates free format character field; all other fields are of a predefined fixed format and content.

TABLE 10-2
NOTIFICATION TRANSFER FILE

(TO BE DETERMINED)

## 10.2 System Status/Warning Message Block Format

The S/S/W Message File contains information relating to MCS and the ORMS system generated A/W/E messages which impact GPS system status or performance from a GPS civil user perspective.

### 10.2.1 Contents Definition

The contents of this file are defined in Table 10-3 and described in Table 10-4. A new file block is associated with each individual S/S/W transferred to the CGIC.

### 10.2.2 Usage

This file serves as a facility for automated GPS navigational status changes. A security mask determines if a message is transmitted in the Short Delay category as a Future or Unscheduled Event Advisory or as a Long Delay S/S/W message block format (see Section 4.1.1.2).

### 10.2.3 Special Requirements

There is no direct support for S/S/W message explanation and interpretation from the MCS on a message by message basis. However, since the definition of the contents of the underlying A/W/E message file evolves over time, it is necessary that the CGS have a method of determining what new messages it requires and a method of obtaining such messages.

TABLE 10-3

SYSTEM STATUS/WARNING MESSAGES
TRANSFER FILE DEFINITIONS

| ITEM | DESCRIPTION |
|---|---|
| Message Number | Unique identifier for the S/S/W message |
| Archive Flag | Flag indicating block has been retrieved from ORMS archive<br>0 = block from regular transmission<br>1 = block retrieved from archive |
| Message Route Code | Routing code for S/S/W message<br>1 = Future Event Advisory<br>2 = Unscheduled Event Advisory<br>3 = Postprocessed Quantity<br>4 = Other (e.g., ORMS only) |
| Time Relevance | Urgency of message (see Section 4.1.1.1.2 and Fig. 2)<br>1 = of immediate usefulness<br>2 = of intermediate interest<br>3 = of historical interest |
| GPS Week Number | Week number associated with time of A/W/E message occurrence, modulo 1024 from GPS Epoch |
| Issue Time as Offset from GPS Week Number | Time of issue associated with A/W/E message occurrence, expressed as seconds from beginning of GPS week number |
| Message Category (Mnemonic) | One of the category types defined in SNT06 providing character identification of alarm category |
| Message Category (Numeric) | One of the category types defined in SNT06 providing integer identification of alarm category |
| Message Text Skeleton | Up to 79 characters of message content including substitutable parameters as derived from message text skeleton |
| Associated Status Display | Up to 80 characters of message content providing additional detail |

TABLE 10-4

SYSTEM STATUS/WARNING MESSAGE

TRANSFER FILE

| ITEM | UNITS/FORMAT | VALUE/RANGE | PRECISION |
|---|---|---|---|
| Message Number | /Integer | 1-99999 | 1 |
| Archive Flag | /Integer | 0-255 | 1 |
| Message Route Code | /Integer | 1-4 | 1 |
| Time Relevance | /Integer | 1-3 | 1 |
| GPS Week Number | Weeks/Integer | 0 to 1023 | 1 |
| Issue Time as Offset from GPS Week Number | Seconds/Real | 0 to 604798.5 | 1.5 |
| Message Category (Mnemonic) | /Character | 1-8 characters (see SNT/06) | 1 |
| Message Category (Numeric) | /Integer | As released | 1 |
| Message Text Skeleton | /Character | 79 characters | N/A |
| Associated Status Display | /Character | 80 characters | N/A |

# 20.0 APPENDIX B
# INTERMEDIATE DELAY TRANSFER BLOCKS

## 20.1 Almanac Transfer Block Format

The Almanac File contains NAV message almanac information as contained in subframe 5, pages 1-24, or subframe 4, pages 2-5 and 7-10.

### 20.1.1 Contents Definition

The contents of this file are defined in Table 20-1 and described in Table 20-2. A new file block is associated with each change in a transmitted almanac parameter set. The contents contain no greater resolution than that available from the corresponding NAV message page.

### 20.1.2 Usage

This file serves as an alternate source for NAV message almanac data. It contains information pertaining to Intermediate Delay data.

### 20.1.3 Special Requirements

None

TABLE 20-1

GPS ALMANAC INTERMEDIATE DELAY TRANSFER FILE DEFINITIONS

| ITEM | DESCRIPTION |
|---|---|
| I. BLOCK INDEX | |
| Block Index | Block index for GPS broadcast almanac (TBD) |
| Version Number | Version number of current block, Version 0 indicates original |
| Transmission Date and Time | Time block transferred (should be assigned by system) |
| Archive Flag | Flag indicating block has been retrieved from ORMS archive<br>0 = block from regular transmission<br>1 = block retrieved from archive |
| II. SV ID | |
| ITEM | DESCRIPTION |
| Transmitting PRN Ref Numbers | See Section 6.0, vector containing PRN reference numbers associated with SVs transmitting the following almanac parameters |
| Transmitting SV NAVSTAR Ref Numbers | See Section 6.0 |
| III. NAV MESSAGE TIME TAGS | |
| ITEM | DESCRIPTION |
| For Each SV: | |
| Initial Broadcast Time (estimated)<br>GPS Week Number<br>Seconds of Week | Estimated time this parameter set began broadcast from this SV |

| | |
|---|---|
| Default Message Transmission Time<br>GPS Week Number<br>Seconds of Week | Time this SV will begin transmitting the default message, all 1's |
| Upload Time<br>GPS Week Number<br>Seconds of Week | Time upload, containing this parameter set, was begun |
| Upload Status Flag | Flag indicating if upload was complete or partial<br>1 designates that a partial upload, containing this parameter set, was performed<br>2 designates that a complete upload was performed |
| Navigation Message Verification Flag | Flag indicating if measurement data received from monitor stations was compared to the upload data, i.e., verification testing performed, before the block release time indicated above.<br>1 designates verification was not attempted<br>2 designates verification was successfully completed<br>3 designates verification was unsuccessful |
| Navigation Message Verification Time<br>GPS Week Number<br>Seconds of Week | Time tag of measurement data used in verification testing; zero if verification not performed |

## IV. NAV MESSAGE PAGES IN BROADCAST FORMAT

| ITEM | DESCRIPTION |
|---|---|
| SV Almanac Message | Almanac message, as broadcast, in NAV message format. See description in ICD-GPS-200 for almanac messages as contained in subframe 5, pages 1-24 or subframe 4, pages 2-5, 7-10. |

## V. NAV MESSAGE PAGES IN ENGINEERING UNITS

| ITEM | DESCRIPTION |
|---|---|
| Roll Momentum Dump/ Alert Flag | Flag has dual role, see ICD-GPS-200, paragraph 20.3.3.2<br>(a) On SVs designated by configuration code 000 - Block I:<br>1 designates a non-conservative momentum dump has occurred since last upload<br>0 designates no momentum dump occurred<br>(b) On SVs designated by configuration code 001 - Block II:<br>1 indicates to the unauthorized user that the SV URA may be worse than indicated in subframe 1 of the NAV message |
| Synchronization/A-S Flag | Flag has dual role, see ICD-GPS-200 paragraph 20.3.3.2<br>(a) On SVs designated by configuration code 000 - Block I:<br>0 indicates that the SV is in synchronism<br>1 indicates that synchronism may not exist<br>(b) On SVs designated by configuration code 001 - Block II:<br>1 indicates that the A-S mode is ON |
| Data ID | Defines the applicable GPS NAV data structure, see ICD-GPS-200, paragraph 20.3.3.5.1.1<br>00 designates data ID one, and is no longer in use<br>01 designates data ID two, which is currently in use |
| SV ID | Defines the content of pages in the GPS NAV message for subframe 4 or 5 to which this SV almanac corresponds, see ICD-GPS-200, paragraph 20.3.3.5.1.1 |
| TOA | Almanac reference time, expressed as seconds from beginning of GPS week |
| e | Orbit eccentricity |
| delta - iota | Correction to inclination angle at reference time, relative to 0.30 semicircles |
| OMEGA0 | Right ascension at reference time |

| | |
|---|---|
| OMEGADOT | Rate of right ascension |
| $(A)^{1/2}$ | Square root of orbit semi-major axis |
| omega | Argument of perigee |
| $M_0$ | Mean anomaly at reference time |
| af0 | Constant term of clock correction polynomial |
| af1 | Coefficient of linear term of clock correction polynomial |
| SV Health | 8-bit SV health status word, see ICD-GPS-200, paragraph 20.3.5.1.3 |

VI. ADDITIONAL INFORMATION
(Not explicitly part of Broadcast Almanac)

| ITEM | DESCRIPTION |
|---|---|
| SV Configuration | SV configuration code, see ICD-GPS-200, paragraph 20.3.3.5.1.6<br>000 = "Block I" SV<br>001 = "Block II" SV |
| WNa | Week number to which almanac reference time is referred, expressed as Z-counts modulo 1024 from GPS epoch |
| AODA | Time difference between reference time of almanac parameter set and time of the last measurement update which contributed to that parameter set, of the form TOA - solution update time |

TABLE 20-2

GPS ALMANAC INTERMEDIATE DELAY TRANSFER FILE

I. Block Index

| ITEM | UNITS/FORMAT | VALUE/RANGE | PRECISION |
|---|---|---|---|
| Block Index | /Integer | TBD | 1 |
| Version Number | TBD | TBD | TBD |
| Transmission Date and Time | TBD | TBD | TBD |
| Archive Flag | /Integer | 0 - 255 | 1 |

II. SV ID

| ITEM | UNITS/FORMAT | VALUE/RANGE | PRECISION |
|---|---|---|---|
| Transmitting PRN Ref Numbers | /Integer | 0 - 37 | 1 |
| Transmitting SV NAVSTAR Ref Numbers | /Integer | 0 - 255 | 1 |

III. NAV MESSAGE TIME TAGS

| ITEM | UNITS/FORMAT | VALUE/RANGE | PRECISION |
|---|---|---|---|
| For Each SV: | | | |
| Initial Broadcast Time (estimated) GPS Week Number | Weeks/Integer | 0 to 1023 | 1 |
| Seconds of Week | Seconds of GPS Week/Real | 0 - 604798.5 | 1.5 |
| Default Message Transmission Time GPS Week Number | Weeks/Integer | 0 to 1023 | 1 |
| Seconds of Week | Seconds of GPS Week/Real | 0 - 604798.5 | 1.5 |

| | | | |
|---|---|---|---|
| Upload Time | | | |
| GPS Week Number | Weeks/Integer | 0 to 1023 | 1 |
| Seconds of Week | Seconds of GPS Week/Real | 0 - 604798.5 | 1.5 |
| Upload Status Flag | /Integer | 1 to 2 | 1 |
| Navigation Message Verification Flag | /Integer | 1 to 3 | 1 |
| Navigation Message Verification Time | | | |
| GPS Week Number | Weeks/Integer | 0 to 1023 | 1 |
| Seconds of Week | Seconds of GPS Week/Real | 0 - 604798.5 | 1.5 |

IV. NAV MESSAGE PAGES IN BROADCAST FORMAT

| ITEM | UNITS/FORMAT | VALUE/RANGE | PRECISION |
|---|---|---|---|
| SV Almanac Message | 10, 30 bit | 0 to $(2^{30}-1)$ | 1 |

V. NAV MESSAGE PAGES IN ENGINEERING UNITS

| ITEM | UNITS/FORMAT | VALUE/RANGE | PRECISION |
|---|---|---|---|
| Roll Momentum Dump/ Alert Flag | /Binary | 0 to 1 | 1 |
| Synchronization/A-S Flag | /Binary | 0 to 1 | 1 |
| Data ID | /Integer | 00 to 11 | 1 |
| SV ID | /Integer | 0 to $2^6-1$ | 1 |
| TOA | Seconds/Integer | 0 to 604799 | 1 |
| e | /Real | TBD | N/A |
| delta - iota | Semicircles/Real | TBD | N/A |

| | | | |
|---|---|---|---|
| OMEGA0 | Semicircles/Real | TBD | N/A |
| OMEGADOT | Semicircles/Sec/Real | TBD | N/A |
| $(A)^{1/2}$ | Meters/Real | TBD | N/A |
| M0 | Semicircles/Real | TBD | N/A |
| omega | Semicircles/Real | TBD | N/A |
| af0 | Seconds/Real | TBD | 1 |
| af1 | Seconds/Real | TBD | 1 |
| SV Health | /Integer | 0 to $2^8$-1 | 1 |

VI. ADDITIONAL INFORMATION

| ITEM | UNITS/FORMAT | VALUE/RANGE | PRECISION |
|---|---|---|---|
| SV Configuration | /Integer | 000 to 111 | 1 |
| WNa | Weeks/Integer | 0 to 1023 | 1 |
| AODA | Seconds/Real | *0-6048000* | 1.5 |

## 20.2 Broadcast Ephemeris Block Format

The Broadcast Ephemeris Transfer File contains NAV message ephemerides as contained in subframes 1, 2, and 3.

### 20.2.1 Contents Definition

The contents of this file are defined in Table 20-3 and described in Table 20-4. A new file block is associated with each change in a transmitted ephemeris parameter set. The contents contain no greater resolution than that available from the corresponding NAV message page.

### 20.2.2 Usage

This file serves as an alternate source for NAV message ephemeris data. It contains information pertaining to Intermediate Delay data.

### 20.2.3 Special Requirements

None

TABLE 20-3

GPS BROADCAST EPHEMERIS INTERMEDIATE DELAY
TRANSFER FILE DEFINITIONS

I. BLOCK INDEX

| ITEM | DESCRIPTION |
|---|---|
| Block Index | Block index for GPS broadcast ephemeris (TBD) |
| Version Number | Version number of current block, Version 0 indicates original |
| Transmission Date and Time | Time block transferred to CGIC (should be assigned by system) |
| Archive Flag | Flag indicating block has been retrieved from ORMS archive<br>0 = block from regular transmission<br>1 = block retrieved from archive |

II. SV IDENTIFICATION

| ITEM | DESCRIPTION |
|---|---|
| Transmitting SV PRN Ref Number | See Section 6.0, PRN number of SV transmitting the following ephemeris parameter |
| Transmitting SV NAVSTAR Ref Number | See Section 6.0 |

III. NAV MESSAGE TIME TAGS

| ITEM | DESCRIPTION |
|---|---|
| Initial Broadcast Time (estimated)<br>GPS Week Number<br>Seconds of Week | Estimated time this parameter set began broadcast from this SV |
| Fit Interval Switch Time<br>GPS Week Number<br>Seconds of Week | Time this SVs current upload is scheduled to cut over from data sets being transmitted every one-hour to four-hour data sets (see ICD-GPS-200, reference paragraph 20.3.4.4) |

| | |
|---|---|
| Default Message Transmission Time<br>GPS Week Number<br>Seconds of Week | Time this SV will begin transmitting the default message, all 1's |
| Upload Time<br>GPS Week Number<br>Seconds of Week | Time upload, containing this parameter set, was begun |
| Upload Status Flag | Flag indicating if upload was complete or partial<br>1 designates that a partial upload, containing this parameter set, was performed<br>2 designates that a complete upload was performed |
| Navigation Message Verification Flag | Flag indicating if measurement data received from monitor stations was compared to the upload data, i.e., verification testing performed, before the block release time indicated above.<br>1 designates verification was not attempted<br>2 designates verification was successfully completed<br>3 designates verification was unsuccessful |
| Navigation Message Verification Time<br>GPS Week Number<br>Seconds of Week | Time tag of measurement data used in verification testing; zero if verification not performed |

## IV. NAV MESSAGE SUBFRAMES IN BROADCAST FORMAT

| ITEM | DESCRIPTION |
|---|---|
| SV Ephemeris Message | Ephemeris message, as broadcast, in NAV message format. See description in ICD-GPS-200 for ephemeris message as contained in subframes 1-3 |

## V. NAV MESSAGE SUBFRAMES IN ENGINEERING UNITS

| ITEM | DESCRIPTION |
|---|---|
| Roll Momentum Dump/ Alert Flag | Flag has dual role, see ICD-GPS-200, paragraph 20.3.3.2<br>(a) On SVs designated by configuration code 000 - Block I:<br>1 designates a non-conservative momentum dump has occurred since last upload<br>0 designates no momentum dump occurred<br>(b) On SVs designated by configuration code 001 - Block II:<br>1 indicates to the unauthorized user that the SV URA may be worse than indicated in subframe 1 of the NAV message |
| Synchronization/A-S Flag | Flag has dual role, see ICD-GPS-200, paragraph 20.3.3.2<br>(a) On SVs designated by configuration code 000 - Block I:<br>0 indicates that the SV is in synchronism<br>1 indicates that synchronism may not exist<br>(b) On SVs designated by configuration code 001 - Block II:<br>1 indicates that the A-S mode is ON |
| Ephemeris Week Number | Week number to which ephemeris reference time is referred, expressed as seconds modulo 1024 from GPS Epoch |
| Code(s) on L2 Channel | Indicates transmission of C/A and/or P on L2, see ICD-GPS-200, paragraph 20.3.3.3.1.2<br>00 = both P and C/A OFF<br>01 = P code ON<br>10 = C/A code ON<br>11 = both P and C/A code ON |
| SV Accuracy, Decoded | Decoded value in meters corresponding to NAV message's coded value for predicted user range accuracy of the SV available to the unauthorized user, user, see ICD-GPS-200, paragraph 20.3.3.1.3 |
| SV Health (6-bits) | 6-bit SV health status word, see ICD-GPS-200, paragraph 20.3.3.3.1.4 |

| | |
|---|---|
| IODC | Issue of data clock, indicates the issue number of the date set, see ICD-GPS-200, paragraph 20.3.3.3.1.5 |
| L2 P Data Flag | Data flag for L2 P-code, see ICD-GPS-200, paragraph 20.3.3.3.1<br>1 designates the NAV data stream was commanded OFF on the P-code of the L2 channel<br>0 designates the NAV data stream was commanded ON on the P-code of the L2 channel to line |
| TGD | Estimated group delay differential, see ICD-GPS-200, paragraph 20.3.3.3.1.8 |
| TOC | Reference time for clock correction polynomial, see ICD-GPS-200, paragraph 20.3.3.3.3 |
| af2 | Coefficient of quadratic term of clock correction polynomial, see ICD-GPS-200, paragraph 20.3.3.3.3 |
| af1 | Coefficient of linear term of clock correction polynomial, see ICD-GPS-200, paragraph 20.3.3.3.3 |
| af0 | Constant term of clock correction polynomial, see ICD-GPS-200, paragraph 20.3.3.3.3 |
| M0 | Mean anomaly at ephemeris reference time, TOE, see ICD-GPS-200, paragraph 20.3.3.4.3, for user algorithm of ephemeris determination |
| delta-n | Mean motion difference from computed value, see ICD-GPS-200, paragraph 20.3.3.4.3, for user algorithm of ephemeris determination |
| e | Orbit eccentricity, see ICD-GPS-200, paragraph 20.3.3.4.3, for user algorithm of ephemeris determination |
| $(A)^{1/2}$ | Square root of SV orbit semi-major axis, see ICD-GPS-200, paragraph 20.3.3.4.3, for user algorithm of ephemeris determination |
| OMEGA0 | Right longitude of ascending node of orbit plane at weekly epoch, see ICD-GPS-200, paragraph 20.3.3.4.3, for user algorithm of ephemeris determination |

| | |
|---|---|
| OMEGADOT | Time rate of change of ascending node's right longitude, OMEGA0, see ICD-GPS-200, paragraph 20.3.3.4.3, for user algorithm of ephemeris determination |
| iota0 | Inclination angle at ephemeris reference time, TOE see ICD-GPS-200, paragraph 20.3.3.4.3, for user algorithm of ephemeris determination |
| IDOT | Time rate of change of inclination angle, iota0 see ICD-GPS-200, paragraph 20.3.3.4.3, for user algorithm of ephemeris determination |
| omega | Argument of SV orbit perigee, see ICD-GPS-200, paragraph 20.3.3.4.3, for user algorithm of ephemeris determination |
| Cuc | Amplitude of the cosine harmonic correction term to the argument of latitude, see ICD-GPS-200, paragraph 20.3.3.4.3, for user algorithm of ephemeris determination |
| Cus | Amplitude of the sine harmonic correction term to the argument of latitude, see ICD-GPS-200, paragraph 20.3.3.4.3, for user algorithm of ephemeris determination |
| Crc | Amplitude of the cosine harmonic correction term to the orbit radius, see ICD-GPS-200, paragraph 20.3.3.4.3, for user algorithm of ephemeris determination |
| Crs | Amplitude of the sine harmonic correction term to the orbit radius, see ICD-GPS-200, paragraph 20.3.3.4.3, for user algorithm of ephemeris determination |
| Cic | Amplitude of the cosine harmonic correction term to the angle of inclination, see ICD-GPS-200, paragraph 20.3.3.4.3, for user algorithm of ephemeris determination |
| Cis | Amplitude of the sine harmonic correction term to the angle of inclination, see ICD-GPS-200, paragraph 20.3.3.4.3, for user algorithm of ephemeris determination |

| | |
|---|---|
| TOE | Reference time for ephemeris parameter set, see ICD-GPS-200, paragraph 20.3.3.4.3, for user algorithm of ephemeris determination |
| IODE | Issue of ephemeris data, indicates the issue number of the data set, see ICD-GPS-200, paragraph 20.3.3.4.1.5 |
| Fit Interval Flag | Data fitting interval (utilization span value plus utilization span extraction, as specified from USER Navigation Control File), see ICD-GPS-200, paragraph 20.3.3.4.3.1<br>0 = 4 hours<br>1 = 6 hours |

IV. ADDITIONAL INFORMATION
(Not specifically part of Broadcast Ephemeris)

| ITEM | DESCRIPTION |
|---|---|
| SV Configuration | SV configuration code, see ICD-GPS-200, paragraph 20.3.3.5.1.6<br>000 = "Block I" SV<br>001 = "Block II" SV |
| AODC | Time difference between reference time of clock correction polynomials and time of the last measurement update which contributed to that polynomial of the form: TOC - solution update time |
| AODE | Time difference between reference time of ephemeris parameter set and time of the last measurement update which contributed to that parameter set of the form: TOE - solution update time |

TABLE 20-4

GPS BROADCAST EPHEMERIS INTERMEDIATE DELAY TRANSFER FILE

I. BLOCK INDEX

| ITEM | UNITS/FORMAT | VALUE/RANGE | PRECISION |
|---|---|---|---|
| Block Index | /Integer | TBD | 1 |
| Version Number | TBD | TBD | TBD |
| Transmission Date and Time | TBD | TBD | TBD |
| Archive Flag | /Integer | 0 - 255 | 1 |

II. SV IDENTIFICATION

| ITEM | UNITS/FORMAT | VALUE/RANGE | PRECISION |
|---|---|---|---|
| Transmitting SV PRN Numbers | /Integer | 0 - 37 | 1 |
| Transmitting SV NAVSTAR Ref Numbers | /Integer | 0 - 255 | 1 |

III. NAV MESSAGE TIME TAGS

| ITEM | UNITS/FORMAT | VALUE/RANGE | PRECISION |
|---|---|---|---|
| Initial Broadcast Time (estimated) GPS Week Number | Weeks/Integer | 0 to 1023 | 1 |
| Seconds of Week | Seconds of GPS Week/Real | 0 - 604798.5 | 1.5 |
| Fit Interval Switch Time GPS Week Number | Weeks/Integer | 0 to 1023 | 1 |
| Seconds of Week | Seconds of GPS Week/Real | 0 - 604798.5 | 1.5 |

| | | | |
|---|---|---|---|
| Default Message Transmission Time | | | |
| GPS Week Number | Weeks/Integer | 0 to 1023 | 1 |
| Seconds of Week | Seconds of GPS Week/Real | 0 - 604798.5 | 1.5 |
| Upload Time | | | |
| GPS Week Number | Weeks/Integer | 0 to 1023 | 1 |
| Seconds of Week | Seconds of GPS Week/Real | 0 - 604798.5 | 1.5 |
| Upload Status Flag | /Integer | 1 to 2 | 1 |
| Navigation Message Verification Flag | /Integer | 1 to 3 | 1 |
| Navigation Message Verification Time | | | |
| GPS Week Number | Weeks/Integer | 0 to 1023 | 1 |
| Seconds of Week | Seconds of GPS Week/Real | 0 - 604798.5 | 1.5 |

IV. NAV MESSAGE SUBFRAMED IN BROADCAST FORMAT

| ITEM | UNITS/FORMAT | VALUE/RANGE | PRECISION |
|---|---|---|---|
| SV Ephemeris Message | /30, 30 Bit Words | 0 to $(2^{30}-1)$ | 1 |

V. NAV MESSAGE SUBFRAMED IN ENGINEERING UNITS

| ITEM | UNITS/FORMAT | VALUE/RANGE | PRECISION |
|---|---|---|---|
| Roll Momentum Dump/ Alert Flag | /Binary | 0 to 1 | 1 |
| Synchronization/A-S Flag | /Binary | 0 to 1 | 1 |
| Ephemeris Week Number | Weeks/Integer | 0 to 1023 | 1 |
| Code(s) on L2 Channel | /Binary | 00 to 11 | 1 |

| | | | |
|---|---|---|---|
| SV Accuracy, Decoded | Meters/Real | .01 to $2^{12}$ | non-contiguous resolution |
| SV Health (6-bits) | /Integer | 0 to $2^6$-1 | 1 |
| IODC | /Integer | 0 to 1023 | 1 |
| L2 P Data Flag | /Binary | 0 to 1 | 1 |
| TGD | Seconds/Real | (8-bits signed) | $2^{-31}$ |
| TOC | Seconds of GPS Week/Integer | 0 - 604784 | $2^4$ |
| af2 | Sec/Sec$^2$ /Real | (8-bits signed*) | $2^{-55}$ |
| af1 | Sec/Sec /Real | (16-bits signed*) | $2^{-43}$ |
| af0 | Seconds/Real | (22-bits signed*) | $2^{-31}$ |
| M0 | Semicircles/Real | (32-bits signed*) | $2^{-31}$ |
| delta-n | Semicircles/Sec /Real | (32-bits signed*) | $2^{-43}$ |
| e | /Real | 0 to 0.03 | $2^{-33}$ |
| $(A)^{1/2}$ | Meters$^{1/2}$/Real | 0 to ($2^{13}$-1) | $2^{-19}$ |
| OMEGA0 | Semicircles/Real | (32-bits signed*) | $2^{-31}$ |
| OMEGADOT | Semicircles/Sec /Real | (24-bits signed*) | $2^{-43}$ |
| iota0 | Semicircles/Real | (32-bits signed*) | $2^{-31}$ |
| IDOT | Semicircles/Sec /Real | (14-bits signed*) | $2^{-43}$ |
| omega | Semicircles/Real | (32-bits signed*) | $2^{-31}$ |
| Cuc | Radians/Real | (16-bits signed*) | $2^{-29}$ |
| Cus | Radians/Real | (16-bits signed*) | $2^{-29}$ |
| Crc | Meters/Real | (16-bits signed*) | $2^{-5}$ |
| Crs | Meters/Real | (16-bits signed*) | $2^{-5}$ |
| Cic | Radians/Real | (16-bits signed*) | $2^{-29}$ |

| | | | |
|---|---|---|---|
| Cis | Radians/Real | (16-bits signed*) | $2^{-29}$ |
| TOE | Seconds of GPS Week/Integer | 0 - 604784 | $2^{4}$ |
| IODE | /Real | 0 to 255 | 1 |
| Fit Interval Flag | /Binary | 0 to 1 | 1 |

VI. ADDITIONAL INFORMATION
(Not explicitly part of Broadcast Ephemeris)

| ITEM | UNITS/FORMAT | VALUE/RANGE | PRECISION |
|---|---|---|---|
| SV Configuration | /Integer | 000 - 111 | 1 |
| AODC | Seconds/Real | 0-604800 | 1.5 |
| AODE | Seconds/Real | 0-604800 | 1.5 |

* Parameters so indicated are transmitted as two's complement, with the sign bit (+ or -) occupying the MSB

## 20.3 Ionospheric and UTC Data Block Format

The ionospheric and UTC data file contains information relating to ionospheric parameters and universal coordinated time parameters as they are broadcast in page 18 of subframe 4 of the GPS NAV message.

### 20.3.1 Contents Definition

The contents of this file are defined in Table 20.5 and described in Table 20-6. A new file block is associated with each change in a transmitted ionospheric and UTC data page, regardless of whether ionospheric or UTC parameters have changed from the previous upload. The contents of the Ionospheric and UTC data file contain no greater resolution than that available from the corresponding NAV message page itself.

### 20.3.2 Usage

This file serves as an alternate source for NAV message ionospheric and UTC data information. UTC data contains the parameters relating to correlating UTC time with GPS time. Ionospheric data allows the "L1 only" or "L2 only" user to computer the ionospheric delay.

### 20.3.3 Special Requirements

None

TABLE 20-5

GPS IONOSPHERIC AND UTC DATA
INTERMEDIATE DELAY TRANSFER FILE DEFINITIONS

I. BLOCK INDEX

| ITEM | DESCRIPTION |
|---|---|
| Block Index | Block index of NAV's ionospheric and UTC data file (TBD) |
| Version Number | Version Number of current block, Version 0 indicates original |
| Transmission Date and Time | Time block transferred to the CGIC (should be assigned by system) |
| Archive Flag | Flag indicating block has been retrieved from ORMS archive<br>0 = block from regular transmission<br>1 = block retrieved from archive |

II. SV IDENTIFICATION

| ITEM | DESCRIPTION |
|---|---|
| Transmitting SV PRN Ref Numbers | See Section 6.0, Vector containing PRN reference numbers associated with SVs transmitting the following ionospheric and UTC data parameters |
| Transmitting SV NAVSTAR Ref Numbers | See Section 6.0 |

III. NAV MESSAGE TIME TAGS

| ITEM | DESCRIPTION |
|---|---|
| For each SV: | |
| Initial Broadcast Time (estimated)<br>GPS Week Number<br>Seconds of Week | Estimated time this parameter set began broadcast from this SV |

| | |
|---|---|
| Default Message Transmission Time<br>GPS Week Number<br>Seconds of Week | Time this SV will begin transmitting the default message, all 1's |
| Upload Time<br>GPS Week Number<br>Seconds of Week | Time upload, containing this parameter set, was begun |
| Upload Status Flag | Flag indicating if upload was complete or partial<br>1 designates that a partial upload, containing this parameter set, was performed<br>2 designates that a complete upload was performed |
| Navigation Message Verification Flag | Flag indicating if measurement data received from monitor stations was compared to the upload data, i.e., verification testing performed, before the block release time indicated above.<br>1 designates verification was not attempted<br>2 designates verification was successfully completed<br>3 designates verification was unsuccessful |
| Navigation Message Verification Time<br>GPS Week Number<br>Seconds of Week | Time tag of measurement data used in verification testing; zero if verification not performed |

## IV. NAV MESSAGE PAGES IN BROADCAST FORMAT

| ITEM | DESCRIPTION |
|---|---|
| Ionospheric and UTC Data Page | Ionospheric and UTC data as contained in page 18 of subframe 4, in NAV message (as broadcast) format; see ICD-GPS-200, paragraphs 20.3.3.5.1.8 and 20.3.3.5.1.9 |

## V. NAV MESSAGE PAGES IN ENGINEERING UNITS

| ITEM | DESCRIPTION |
|---|---|
| Roll Momentum Dump/ Alert Flag | Flag has dual role, see ICD-GPS-200, paragraph 20.3.3.2<br>(a) On SVs designated by configuration code 000 - Block I:<br>1 designates a non-conservative momentum dump has occurred since last upload<br>0 designates no momentum dump occurred<br>(b) On SVs designated by configuration code 001 - Block II:<br>1 indicates to the unauthorized user that the SV URA may be worse than indicated in subframe 1 of the NAV message |
| Synchronization/A-S Flag | Flag has dual role, see ICD-GPS-200, paragraph 20.3.3.2<br>(a) On SVs designated by configuration code 000 - Block I:<br>0 indicates that the SV is in synchronism<br>1 indicates that synchronism may not exist<br>(b) On SVs designated by configuration code 001 - Block II:<br>1 indicates that the A-S mode is ON |
| Data ID | Defines the applicable GPS NAV data structure, see ICD - GPS-200, paragraph 20.3.3.5.1.1<br>00 designates data ID one, and is no longer in use<br>01 designates data ID two, which is currently in use |
| SV ID | Defines the content of pages in the GPS NAV message for subframe 4 or 5 to which this SV almanac corresponds, see ICD-GPS-200, paragraph 20.3.3.5.1.1 |
| Alpha0 | Coefficients of ionospheric model, see ICD-GPS-200, paragraph 20.3.3.5.2.5 for user ionospheric model |

| | |
|---|---|
| Alpha1 | (same as Alpha0) |
| Alpha2 | (same as Alpha0) |
| Alpha3 | (same as Alpha0) |
| Beta0 | (same as Alpha0) |
| Beta1 | (same as Alpha0) |
| Beta2 | (same as Alpha0) |
| Beta3 | (same as Alpha0) |
| $A_1$ | Drift between GPS time and UTC |
| $A_0$ | Bias between GPS time and UTC |
| $t_{ot}$ | Reference time-of-day for GPS time to UTC relationship |
| $WN_t$ | Reference week number for GPS time to UTC relationship |
| delta $t_{LS}$ | Integer number of seconds between UTC and GPS time |
| $WN_{LSF}$(10-bit) | Leap second advisory's effective week number, untruncated |
| DN | Leap second advisory's effective day number |
| delta $t_{LSF}$ | Leap second advisory's delta time due to leap seconds |

VI. ADDITIONAL INFORMATION
(Not explicitly part of the Ionospheric & UTC Data Page)

| ITEM | DESCRIPTION |
|---|---|
| SV Configuration | SV configuration code, see ICD-GPS-200, paragraph 20.3.3.5.1.6<br>000 = "Block I" SV<br>001 = "Block II" SV |

| | |
|---|---|
| AODI | Time difference between upload time and time of last atmospheric measurement update which contributed to the ionospheric coefficients; of the form: upload time - solution update time in seconds |
| AODL | Effective date-time in GPS time of leap-second count, delta $t_{LS}$, update |
| AODU | Time difference between reference time for GPS time to UTC relationship and time of last measurement update which contributed to the $A_0$ and $a_1$ coefficients; of the form: $t_{ot}$ - solution update time, in seconds |

TABLE 20-6

GPS IONOSPHERIC AND UTC DATA
INTERMEDIATE DELAY TRANSFER FILE

I. BLOCK INDEX

| ITEM | UNITS/FORMAT | VALUE/RANGE | PRECISION |
|---|---|---|---|
| Block Index | /Integer | TBD | 1 |
| Version Number | TBD | TBD | TBD |
| Transmission Date and Time | TBD | TBD | TBD |
| Archive Flag | /Integer | 0 - 255 | 1 |

II. SV IDENTIFICATION

| ITEM | UNITS/FORMAT | VALUE/RANGE | PRECISION |
|---|---|---|---|
| Transmitting SV PRN Ref Numbers | /Integer | 0 - 37 | 1 |
| Transmitting SV NAVSTAR Ref Numbers | /Integer | 0 - 255 | 1 |

III. NAV MESSAGE TIME TAGS

| ITEM | UNITS/FORMAT | VALUE/RANGE | PRECISION |
|---|---|---|---|
| For each SV: | | | |
| Initial Broadcast Time (estimated) GPS Week Number | Weeks/Integer | 0 to 1023 | 1 |
| Seconds of Week | Seconds of GPS GPS Week/Real | 0 - 604798.5 | 1.5 |
| Default Message Transmission Time GPS Week Number | Weeks/Integer | 0 to 1023 | 1 |
| Seconds of Week | Seconds of GPS Week/Real | 0 - 604798.5 | 1.5 |

| | | | |
|---|---|---|---|
| Upload Time GPS Week Number | Weeks/Integer | 0 to 1023 | 1 |
| Seconds of Week | Seconds of GPS Week/Real | 0 - 604798.5 | 1.5 |
| Upload Status Flag | /Integer | 1 to 2 | 1 |
| Navigation Message Verification Flag | /Integer | 1 to 3 | 1 |
| Navigation Message Verification Time GPS Week Number | Weeks/Integer | 0 to 1023 | 1 |
| Seconds of Week | Seconds of GPS Week/Real | 0 - 604798.5 | 1.5 |

IV. NAV MESSAGE PAGES IN BROADCAST FORMAT

| ITEM | UNITS/FORMAT | VALUE/RANGE | PRECISION |
|---|---|---|---|
| Ionospheric and UTC Data Page (as broadcast) | /10, 30 bit words | 0 to $(2^{30}-1)$ | 1 |

V. NAV MESSAGE PAGES IN ENGINEERING UNITS

| ITEM | UNITS/FORMAT | VALUE/RANGE | PRECISION |
|---|---|---|---|
| Roll Momentum Dump/ Alert Flag | /Binary | 0 to 1 | 1 |
| Synchronization/A-S Flag | /Binary | 0 to 1 | 1 |
| Data ID | /Integer | 00 to 11 | 1 |
| SV ID | /Integer | 0 to $2^6-1$ | 1 |
| Alpha0 | Seconds/Real | (8-bits signed*) | $2^{-30}$ |
| Alpha1 | Sec/Semicircle/Real | (8-bits signed*) | $2^{-27}$ |
| Alpha2 | Sec/Semicircle$^2$/Real | (8-bits signed*) | $2^{-24}$ |
| Alpha3 | Sec/Semicircle$^3$/Real | (8-bits signed*) | $2^{-24}$ |

| | | | |
|---|---|---|---|
| Beta0 | Seconds/Real | (8-bits signed*) | $2^{11}$ |
| Beta1 | Sec/Semicircle/Real | (8-bits signed*) | $2^{14}$ |
| Beta2 | Sec/Semicircle$^2$/Real | (8-bits signed*) | $2^{16}$ |
| Beta3 | Sec/Semicircle$^3$/Real | (8-bits signed*) | $2^{16}$ |
| $A_1$ | Seconds/Real | (32-bits signed*) | $2^{-30}$ |
| $A_0$ | Sec/Sec /Real | (24-bits signed*) | $2^{-50}$ |
| $t_{ot}$ | Seconds/Real | 0 to 602,112 | $2^{12}$ |
| $WN_t$ | Weeks/Integer | 0 to 1023 | 1 |
| delta $t_{LS}$ | Seconds/Integer | (8-bits signed*) | 1 |
| $WN_{LSF}$ (10-bit) | Weeks/Integer | 0 to 1023 | 1 |
| DN | Days/Integer | 1-7 | 1 |
| delta $t_{LSF}$ | Seconds/Integer | (8-bits signed*) | 1 |

VI. ADDITIONAL INFORMATION
(Not explicitly part of the Ionospheric & UTC Data Page)

| ITEM | UNITS/FORMAT | VALUE/RANGE | PRECISION |
|---|---|---|---|
| SV Configuration | /Integer | 000-111 | 1 |
| AODI | Seconds/Real | 0-604800 | 1.5 |
| AODL | Seconds/Real | 0-6X10$^6$ | 1.5 |

## 20.4 Special Message Block Format

The Special Message Transfer File contains NAV message textual information as contained on page 17 of subframe 4.

### 20.4.1 Contents Definition

The contents of this file are defined in Table 20-7 and described in Table 20-8 . A new file block is associated with each change in a transmitted special message.

### 20.4.2 Usage

This file serves as an alternate source for special NAV messages. It contains information pertaining to Intermediate Delay Data.

### 20.4.3. Special Requirements

The contents of a special message will generate the creation of an CGIC S/S/W.

TABLE 20-7

GPS SPECIAL MESSAGE INTERMEDIATE DELAY
TRANSFER FILE DEFINITIONS

I. BLOCK INDEX

| ITEM | DESCRIPTION |
|---|---|
| Block Index | Block index for NAV's special message (TBD) |
| Version Number | Version number of current block, Version 0 indicates original |
| Transmission Data | Time block transferred to the CGIC (should be assigned by system) |
| Archive Flag | Flag indicating block has been retrieved from ORMS archive<br>0 = block from regular transmission<br>1 = block retrieved from archive |

II. SV IDENTIFICATION

| ITEM | DESCRIPTION |
|---|---|
| Transmitting SV PRN Ref Numbers | See Section 6.0, vector containing PRN reference numbers associated with SVs transmitting the following Special Message page |
| Transmitting SV NAVSTAR Ref Numbers | See Section 6.0 |

III. NAV MESSAGE TIME TAGS

| ITEM | DESCRIPTION |
|---|---|
| For each SV: | |
| Initial Broadcast Time (estimated)<br>GPS Week Number<br>Seconds of Week | Estimated time this parameter set began broadcast from this SV |

| | |
|---|---|
| Default Message Transmission Time<br>GPS Week Number<br>Seconds of Week | Time this SV will begin transmitting the default message, all 1's |
| Upload Time<br>GPS Week Number<br>Seconds of Week | Time upload, containing this parameter set, was begun |
| Upload Status Flag | Flag indicating if upload was complete or partial<br>1 designates that a partial upload, containing this parameter set, was performed<br>2 designates that a complete upload was performed |
| Navigation Message Verification Flag | Flag indicating if measurement data received from monitor stations was compared to the upload data, i.e., verification testing performed, before the block release time indicated above.<br>1 designates verification was not attempted<br>2 designates verification was successfully completed<br>3 designates verification was unsuccessful |
| Navigation Message Verification Time<br>GPS Week Number<br>Seconds of Week | Time tag of measurement data used in verification testing; zero if verification not performed |

## IV. NAV MESSAGE PAGES IN BROADCAST FORMAT

| ITEM | DESCRIPTION |
|---|---|
| Special Message Page | Special message page, as contained in page 17 of subframe 4, in NAV message format, see ICD-GPS-200, paragraph 20.3.3.5.1.10 |

## V. NAV MESSAGE PAGES IN ENGINEERING UNITS

| ITEM | DESCRIPTION |
|---|---|
| Roll Momentum Dump/ Alert Flag | Flag has dual role, see ICD-GPS-200, paragraph 20.3.3.2<br>(a) On SVs designated by configuration code 000 - Block I:<br>1 designates a non-conservative momentum dump has occurred since last upload<br>0 designates no momentum dump occurred<br>(b) On SVs designated by configuration code 001 - Block II:<br>1 indicates to the unauthorized user that the SV URA may be worse than indicated in subframe 1 of the NAV message |
| Synchronization/A-S Flag | Flag has dual role, see ICD-GPS-200, paragraph 20.3.3.2<br>(a) On SVs designated by configuration code 000 - Block I:<br>0 indicates that the SV is in synchronism<br>1 indicates that synchronism may not exist<br>(b) On SVs designated by configuration code 001 - Block II:<br>1 indicates that the A-S mode is ON |
| Data ID | Defines the applicable GPS NAV data structure, see ICD - GPS-200, paragraph 20.3.3.5.1.1<br>00 designates data ID one, and is no longer in use<br>01 designates data ID two, which is currently in use |
| SV ID | Defines the content of pages in the GPS NAV message for subframe 4 or 5 to which this SV almanac corresponds, see ICD-GPS-200, paragraph 20.3.3.5.1.1 |
| Special Message (unpacked) | Unpacked special message, containing 22 8-bit ASCII characters, see ICD-GPS-200, paragraph 20.3.3.5.10 |

VI. ADDITIONAL INFORMATION
(Not explicitly part of the special message)

| ITEM | DESCRIPTION |
|---|---|
| SV Configuration | SV configuration code, see ICD-GPS-200, paragraph 20.3.3.5.1.6<br>000 = "Block I" SV<br>001 = "Block II" SV |
| AODM | Age of data message |

TABLE 20-8

GPS SPECIAL MESSAGE INTERMEDIATE DELAY
TRANSFER FILE

I. BLOCK INDEX

| ITEM | UNITS/FORMAT | VALUE/RANGE | PRECISION |
|---|---|---|---|
| Block Index | /Integer | TBD | 1 |
| Version Number | TBD | TBD | TBD |
| Transmission Date and Time | TBD | TBD | TBD |
| Archive Flag | /Integer | 0 - 255 | 1 |

II. SV IDENTIFICATION

| ITEM | UNITS/FORMAT | VALUE/RANGE | PRECISION |
|---|---|---|---|
| Transmitting SV PRN Ref Numbers | /Integer | 0 - 37 | 1 |
| Transmitting SV NAVSTAR Ref Numbers | /Integer | 0 - 255 | 1 |

III. NAV MESSAGE TIME TAGS

| ITEM | UNITS/FORMAT | VALUE/RANGE | PRECISION |
|---|---|---|---|
| For each SV: | | | |
| Initial Broadcast Time (estimated) | | | |
| GPS Week Number | Weeks/Integer | 0 to 1023 | 1 |
| Seconds of Week | Seconds of GPS Week/Real | 0 - 604798.5 | 1.5 |
| Default Message Transmission Time | | | |
| GPS Week Number | Weeks/Integer | 0 to 1023 | 1 |
| Seconds of Week | Seconds of GPS Week/Real | 0 - 604798.5 | 1.5 |

| | | | |
|---|---|---|---|
| Upload Time | | | |
| GPS Week Number | Weeks/Integer | 0 to 1023 | 1 |
| Seconds of Week | Seconds of GPS Week/Real | 0 - 604798.5 | 1.5 |
| Upload Status Flag | /Integer | 1 to 2 | 1 |
| Navigation Message Verification Flag | /Integer | 1 to 3 | 1 |
| Navigation Message Verification Time | | | |
| GPS Week Number | Weeks/Integer | 0 to 1023 | 1 |
| Seconds of Week | Seconds of GPS Week/Real | 0 - 604798.5 | 1.5 |

IV. NAV MESSAGE PAGES IN BROADCAST FORMAT

| ITEM | UNITS/FORMAT | VALUE/RANGE | PRECISION |
|---|---|---|---|
| Special Message Page | /10, 30-bit words words | 0 to $(2^{30}-1)$ | 1 |

V. NAV MESSAGE PAGES IN ENGINEERING UNITS

| ITEM | UNITS/FORMAT | VALUE/RANGE | PRECISION |
|---|---|---|---|
| Roll Momentum Dump/ Alert Flag | /Binary | 0 to 1 | 1 |
| Synchronization/A-s Flag | /Binary | 0 to 1 | 1 |
| Data ID | /Integer | 00 to 11 | 1 |
| SV ID | /Integer | 0 to $2^6-1$ | 1 |
| Special Message (unpacked) | /Character | 22 characters | N/A |

VI. ADDITIONAL INFORMATION
(Not explicitly part of the Special Message)

| ITEM | UNITS/FORMAT | VALUE/RANGE | PRECISION |
|---|---|---|---|
| SV Configuration | /Integer | 000-111 | 1 |
| AODM | Seconds/Real | 0-6048001 | 1.5 |

## 20.5 Health and A-S/Configuration Block Format

The SV health and A-S/configuration data file contains information relating to SV state of health, and A-S and SV configuration parameters as they are broadcast in page 25 of subframe 5 and page 25 of subframe 4 of the GPS NAV message.

### 20.5.1 Contents Definition

The contents of this file are defined in Table 20-9 and described in Table 20-10. A new file block is generated for each change in a transmitted page 25 set, regardless of whether the change occurs in either subframe 4 or 5. The contents of the SV Health and A-S/configuration data file contains no greater resolution than that available from the NAV message itself.

### 20.5.2 Usage

This file serves as an alternate source for NAV message pages 25 of subframes 4 and 5.

### 20.5.3 Special Requirements

None

TABLE 20-9

SV HEALTH AND A-S DATA INTERMEDIATE DELAY
TRANSFER FILE DEFINITIONS

I. BLOCK INDEX

| ITEM | DESCRIPTION |
|---|---|
| Block Index | Block index for SV Health and A-S/Configuration Data Block (TBD) |
| Version Number | Version number of current block, Version 0 indicates original |
| Transmission Date and Time | Time block transferred to the CGIC (should be assigned by system) |
| Archive Flag | Flag indicating block has been retrieved from ORMS archive<br>0 = block from regular transmission<br>1 = block retrieved from archive |

II. SV IDENTIFICATION

| ITEM | DESCRIPTION |
|---|---|
| Transmitting SV PRN Ref Numbers | See Section 6.0, vector PRN reference numbers associated with SVs transmitting the following set of pages 25 of subframes 4 and 5 |
| Transmitting SV NAVSTAR Ref Numbers | See Section 6.0 |

III. NAV MESSAGE TIME TAGS

| ITEM | DESCRIPTION |
|---|---|
| For each SV: | |
| Initial Broadcast Time (estimated)<br>GPS Week Number<br>Seconds of Week | Estimated time this parameter set began broadcast from this SV |

| | |
|---|---|
| Default Message Transmission Time<br>GPS Week Number<br>Seconds of Week | Time this SV will begin transmitting the default message, all 1's |
| Upload Time<br>GPS Week Number<br>Seconds of Week | Time upload, containing this parameter set, was begun |
| Upload Status Flag | Flag indicating if upload was complete or partial<br>1 designates that a partial upload, containing this parameter set, was performed<br>2 designates that a complete upload was performed |
| Navigation Message Verification Flag | Flag indicating if measurement data received from monitor stations was compared to the upload data, i.e., verification testing performed, before the block release time indicated above.<br>1 designates verification was not attempted<br>2 designates verification was successfully completed<br>3 designates verification was unsuccessful |
| Navigation Message Verification Time<br>GPS Week Number<br>Seconds of Week | Time tag of measurement data used in verification testing; zero if verification not performed |

## IV. NAV MESSAGE PAGES IN BROADCAST FORMAT

| ITEM | DESCRIPTION |
|---|---|
| SV Health and A-S/Configuration data pages (in broadcast format) | SV Health and A-S data pages as contained in pages 25 of subframes 4 and 5 of the NAV message, stored page 25 of subframe 4, then page 25 of subframe 5; see ICD-GPS-200, paragraphs 20.3.3.5.1.3 and 20.3.3.5.1.6 |

## V. NAV MESSAGE PAGES IN ENGINEERING UNITS

| ITEM | DESCRIPTION |
|---|---|
| Roll Momentum Dump/ Alert Flag (from subframe 4) | Flag has dual role, see ICD-GPS-200, paragraph 20.3.3.2<br>(a) On SVs designated by configuration code 000 - Block I:<br>1 designates a non-conservative momentum dump has occurred since last upload<br>0 designates no momentum dump occurred<br>(b) On SVs designated by configuration code 001 - Block II:<br>1 indicates to the unauthorized user that the SV URA may be worse than indicated in subframe 1 of the NAV message |
| Synchronization/A-S Flag (from subframe 4) | Flag has dual role, see ICD-GPS-200, paragraph 20.3.3.2<br>(a) On SVs designated by configuration code 000 - Block I:<br>0 indicates that the SV is in synchronism<br>1 indicates that synchronism may not exist<br>(b) On SVs designated by configuration code 001 - Block II:<br>1 indicates that the A-S mode is ON |
| Data ID (from subframe 4) | Defines the applicable GPS NAV data structure, see ICD - GPS-200, paragraph 20.3.3.5.1.1<br>00 designates data ID one, and is no longer in use<br>01 designates data ID two, which is currently in use |
| SV ID (from subframe 4) | Defines the content of pages in the GPS NAV message for subframe 4 or 5 to which this SV almanac corresponds, see ICD-GPS-200, paragraph 20.3.3.5.1.1 |

| | |
|---|---|
| Roll Momentum Dump/ Alert Flag (from subframe 5) | Flag has dual role, see ICD-GPS-200, paragraph 20.3.3.2<br>(a) On SVs designated by configuration code 000 - Block I:<br>1 designates a non-conservative momentum dump has occurred since last upload<br>0 designates no momentum dump occurred<br><br>(b) On SVs designated by configuration code 001 - Block II:<br>1 indicates to the unauthorized user that the SV URA may be worse than indicated in subframe 1 of the NAV message |
| Synchronization/A-S Flag (from subframe 5) | Flag has dual role, see ICD-GPS-200, paragraph 20.3.3.2<br>(a) On SVs designated by configuration code 000 - Block I:<br>0 indicates that the SV is in synchronism<br>1 indicates that synchronism may not exist<br>(b) On SVs designated by configuration code 001 - Block II:<br>1 indicates that the A-S mode is ON |
| Data ID (from subframe 5) | Defines the applicable GPS NAV data structure, see ICD - GPS-200, paragraph 20.3.3.5.1.1<br>00 designates data ID one, and is no longer in use<br>01 designates data ID two, which is currently in use |
| SV ID (from subframe 5) | Defines the content of pages in the GPS NAV message for subframe 4 or 5 to which this SV almanac corresponds, see ICD-GPS-200, paragraph 20.3.3.5.1.1 |
| $t_{ot}$ | Almanac reference time; see ICD-GPS-200, paragraph 20.3.3.5.1.7 |
| $WN_A$ (10-bit) | Almanac reference week, untruncated; see ICD-GPS-200, paragraph 20.3.3.5.1.7 |

| | |
|---|---|
| Health/A-S/ Configuration Vector Elements | One vector for each of the 32 SV #'s in pages 25 of subframes 4 and 5 |
| SV | SV # from pages 25 of subframes 4 and 5<br>NOTE: there may be data regarding another SV in the SV position -- see paragraph 20.3.3.5.1.1 in the ICD-GPS-200 |
| Health Summary | Summary of health of the SV, see ICD-GPS-200, paragraph 20.3.3.5.1.3 |
| 6-bit Health | 6-bit health information for the SV, see ICD-GPS-200, paragraph 20.3.3.5.1.3 |
| Anti-Spoof Flag | Status as determined from 1-bit A-S flag, see ICD-GPS-200, paragraph 20.3.3.5.1.6<br>0 designates A-S flag is a "0" for the SV<br>1 designates A-S flag is a "1" for the SV |
| SV Configuration | Configuration for each SV, see ICD-GPS-200, paragraph 20.3.3.5.1.6<br>000 = "Block I" SV<br>001 = "Block II" SV |

VI. ADDITIONAL INFORMATION
(Not explicitly part of the SV Health and A-S Configuration data page)

| ITEM | DESCRIPTION |
|---|---|
| AODH | Time difference between upload time and time of last SV health update information which contributed to the SV 6-bit health status; of the form: page 25, subframe 5 upload time - last SV health update |

TABLE 20-10

SV HEALTH AND A-S DATA INTERMEDIATE DELAY TRANSFER FILE

I. BLOCK INDEX

| ITEM | UNITS/FORMAT | VALUE/RANGE | PRECISION |
|---|---|---|---|
| Block Index | /Integer | TBD | 1 |
| Version Number | TBD | TBD | TBD |
| Transmission Date and Time | TBD | TBD | TBD |
| Archive Flag | /Integer | 0 - 255 | 1 |

II. SV IDENTIFICATION

| ITEM | UNITS/FORMAT | VALUE/RANGE | PRECISION |
|---|---|---|---|
| Transmitting SV PRN Ref Numbers | /Integer | 0 - 37 | 1 |
| Transmitting SV NAVSTAR Ref Numbers | /Integer | 0 - 255 | 1 |

III. NAV MESSAGE TIME TAGS

| ITEM | UNITS/FORMAT | VALUE/RANGE | PRECISION |
|---|---|---|---|
| For each SV: | | | |
| Initial Broadcast Time (estimated) GPS Week Number | Weeks/Integer | 0 to 1023 | 1 |
| Seconds of Week | Seconds of GPS Week/Real | 0 - 604798.5 | 1.5 |
| Default Message Transmission Time GPS Week Number | Weeks/Integer | 0 to 1023 | 1 |
| Seconds of Week | Seconds of GPS Week/Real | 0 - 604798.5 | 1.5 |

| | | | |
|---|---|---|---|
| Upload Time<br>GPS Week Number | Weeks/Integer | 0 to 1023 | 1 |
| Seconds of Week | Seconds of GPS Week/Real | 0 - 604798.5 | 1.5 |
| Upload Status Flag | /Integer | 1 to 2 | 1 |
| Navigation Message Verification Flag | /Integer | 1 to 3 | 1 |
| Navigation Message Verification Time<br>GPS Week Number | Weeks/Integer | 0 to 1023 | 1 |
| Seconds of Week | Seconds of GPS Week/Real | 0 - 604798.5 | 1.5 |

IV. NAV MESSAGE PAGES IN BROADCAST UNITS

| ITEM | UNITS/FORMAT | VALUE/RANGE | PRECISION |
|---|---|---|---|
| SV Health and A-S/ Configuration Data Pages (in broadcast format) | 20, 30-bit Words | 0 to $(2^{30}-1)$ | 1 |

V. NAV MESSAGE PAGES IN ENGINEERING UNITS

| ITEM | UNITS/FORMAT | VALUE/RANGE | PRECISION |
|---|---|---|---|
| Roll Momentum Dump/ Alert Flag (from subframe 4) | /Binary | 0 to 1 | 1 |
| Synchronization/A-S Flag (from subframe 4) | /Binary | 0 to 1 | 1 |
| Data ID (from subframe 4) | /Integer | 00 to 11 | 1 |

| | | | |
|---|---|---|---|
| SV ID (from subframe 4) | /Integer | 0 to $2^6$-1 | 1 |
| Roll Momentum Dump/ Alert Flag (from subframe 5) | /Binary | 0 to 1 | 1 |
| Synchronization/A-S Flag (from subframe 5) | /Binary | 0 to 1 | 1 |
| Data ID (from subframe 5) | /Integer | 00 to 11 | 1 |
| SV ID (from subframe 5) | /Integer | 0 to $2^6$-1 | 1 |
| $t_{ot}$ | Seconds/Real | 0 to 602,112 | 2 |
| $WN_t$ | Weeks/Integer | 0 to 1023 | 1 |
| Health/A-S/ Configuration Vector Elements: | 32 Vectors, each of the format: | | |
| SV | /Integer | I to 32 | 1 |
| Health Summary | /Integer | 0 to 2 | 1 |
| 6-bit Health | /Integer | Binary (000000 to 111111) | 1 |
| Anti-Spoof Flag | /Binary | 0 to 1 | 1 |
| SV Configuration | /Integer | Binary (000 to 111) | 1 |

VI. ADDITIONAL INFORMATION
(Not explicitly part of the SV Health and A-S/Configuration Data Page)

| ITEM | UNITS/FORMAT | VALUE/RANGE | PRECISION |
|---|---|---|---|
| AODH | Seconds/Real | 0-6048001 | 1.5 |

## 20.6 Spare Page Block Format

The following describes files which contain NAV message pages 13, 14, and 15 of subframe 4.

### 20.6.1 Contents Definition

The contents of this file are defined in Table 20-11 (TBD) and described in Table 20-12 (TBD). A new file block is associated with each change in a transmitted page. The contents of each page in this file are presented in only the downlink broadcast format.

### 20.6.2 Usage

This file serves as an alternate source for the NAV message pages it contains. Its contents currently contain only spare pages. This format is instituted so that in the event of changes, information will be immediately available to CGIC users, though only in the packed broadcast format.

### 20.6.3 Special Requirements

The definition of this file will need to be updated whenever any spare location in pages 13, 14, and 15 of subframe 4 are redesignated as non-reserved fields containing useful information from the standpoint of a civil GPS user.

TABLE 20-11

SPARE PAGE BLOCK FORMAT
INTERMEDIATE DELAY TRANSFER FILE DEFINITIONS

(TO BE DETERMINED)

TABLE 20-12

SPARE PAGE BLOCK FORMAT
INTERMEDIATE DELAY TRANSFER FILE

(TO BE DETERMINED)

# 30.0 APPENDIX C
# LONG DELAY TRANSFER BLOCKS

## 30.1 Performance Information

### 30.1.1 SV Health Plan/History Block Format

The SV Health Plan/History is a list of navigation oriented manual assessments and SV alerts as generated by the OCS. The file contains both planned data and historical actual data.

#### 30.1.1.1 Contents Definition

The items in a SV Health Plan/History transfer block are defined in Table 30-1 and identified in Table 30-2. Blocks are transferred at least every TBD days to the CGS.

#### 30.1.1.2 Usage

This file provides monitored signal health information used in determining an SV health status code.

#### 30.1.1.3 Special Requirements

None

TABLE 30-1

SV HEALTH PLAN/HISTORY LONG DELAY
TRANSFER FILE DEFINITIONS

| ITEM | DESCRIPTION |
|---|---|
| SV Reference Number | See Section TBD |
| Archive Flag | Flag indicating block has been retrieved from ORMS archive<br>0 = block from regular transmission<br>1 = block retrieved from archive |
| Time | Time that entry occurred. |
| Alert Counter | Number of alerts that correlated to the entry. |
| Entry Status | Identifies the future versus actual status. Zero means future. One means late. Two means actual. |
| NAV Signal Health | Value for upload shall be defined defined by Table 20-VII of the ICD-GPS-200. Manually entered by OCS. |
| SV Signal Health | Value for upload shall be defined by Table 20-VIII of the ICD-GPS-202. Derived from other entry data as defined in section 3.1.38.1.1 of the ICD-MCS-301. |
| OCS Vehicle Assessment | Manual assessment of SV operational status. See vehicle assessment definitions, Table LXXV of the ICD-MCS-301. |
| OCS Navigation Summary | Manual assessment of navigation performance. Zero means active. One means usable. Two means unusable. |
| Link 1/2 - P/C | OCS manual assessment of link performance composed of the following items. |
| Modulation | Indicates data modulation status. Zero means on, one means off. |

| | |
|---|---|
| Assessment | Signal power assessment for use in SV signal health. Zero means full, one means usable, two means unusable, and three means off or dead. |
| Alert Code | Defines the reason for the entry. See alert code/magnitude definitions, Table LXXVI of the OCD-MCS-301 |
| Magnitude | Magnitude value for alert. See alert code/magnitude definitions, Table LXXVI of the ICD-MCS-301 |

TABLE 30-2

SV HEALTH PLAN/HISTORY LONG DELAY
TRANSFER FILE

| ITEM | UNITS/FORMAT | VALUE/RANGE | PRECISION |
|---|---|---|---|
| SV Reference Number | Integer | 0-255 | 1 |
| Archive Flag | /Integer | 0-255 | 1 |
| Time | | | |
| GPS Week number | Weeks/Integer | $1-2^{10}-1$ | 2 |
| Seconds of GPS Week | Seconds/Real | 1-604798.5 | 1.5 |
| Alert Counter | Integer | 0-255 | 1 |
| Entry Status | Integer | 0-2 | 1 |
| NAV Signal Health (1) | Integer | 0-7 | 1 |
| SV Signal Health (1) | Integer | 0-31 | 1 |
| Vehicle Assessment (1) | Integer | 0-15 | 1 |
| Navigation Summary (1) | Integer | 0-2 | 1 |
| Link 1-P (1) | | | |
| Modulation | Integer | 0-1 | 1 |
| Assessment | Integer | 0-3 | 1 |
| Link 1-C (1) | | | |
| Modulation | Integer | 0-1 | 1 |
| Assessment | Integer | 0-3 | 1 |
| Link 2-P (1) | | | |
| Modulation | Integer | 0-1 | 1 |
| Assessment | Integer | 0-3 | 1 |
| Link 2-C (1) | | | |
| Modulation | Integer | 0-1 | 1 |
| Assessment | Integer | 0-3 | 1 |

| | | | |
|---|---|---|---|
| Alert Code | Integer | 0-255 | 1 |
| Magnitude | Byte | 64 bytes | N/A |

### 30.1.2 Observed Range Deviations (ORD) Data Block Format

The ORD data file provides a civil GPS user, post facto, with ORD performance information characterizing the quality of GPS monitored data using the ephemeris and clock parameters contained in subframe 1, 2, and 3 of the Navigation message of the transmitting SV.

#### 30.1.2.1 Contents Definition

The contents of ORD data transfer block are defined in Table 30-3 and described in Table 30-4. One block is created and transferred to the CGIC for every TBD Kalman update interval.

#### 30.1.2.2 Usage

This file provides a GPS civil user with MCS determined ORDs versus time.

#### 30.1.2.3 Special Requirements

None

TABLE 30-3

ORD DATA LONG DELAY
TRANSFER FILE DEFINITIONS

| ITEM | DESCRIPTION |
|---|---|
| ORD Data<br>For each monitor station | |
| GS Reference Number | See Section (TBD) |
| Time of ORD | GPS time of Kalman interval containing ionospherically-corrected, smoothed, calibrated pseudo-range; in GPS weeks and seconds of weeks. |
| AOD | Time difference between time of ORD and time of the last measurement update which contributed to the broadcast ephemeris set used in the ORD; of the form: time of ORD - solution update time |
| For each SV measured by monitor station | |
| SV Reference Number | See Section 6.0 |
| ORD from SA contaminated data | Observed range deviation from data contaminated by selective availability |
| Alarm | Flag, set if either non-Sa or SA observed range deviation exceeds its tolerance threshold |
| Archive Flag | Flag indicating block has been retrieved from ORMS archive<br>0 = block from regular transmission<br>1 = block retrieved from archive |

TABLE 30-4

ORD DATA LONG DELAY
TRANSFER FILE

| ITEM | UNITS/FORMAT | VALUE/RANGE | PRECISION |
|---|---|---|---|
| ORD Data | | | |
| For each monitor station: | | | |
| GS Reference Number (MS ID) | Integer | 0-255 | 1 |
| Time of ORD | GPS Time | N/A | DP |
| AOD | Seconds | N/A | DP |
| For each SV measured by monitor station | | | |
| SV Reference Number | Integer | 0-255 | 1 |
| ORD from SA contaminated data | Meters | N/A | DP |
| Alarm | Flag | 0 or 1 | 1 |
| Archive Flag | /Integer | 0-255 | 1 |

### 30.1.3 Estimated Range Deviations (ERD) Data Block Format

The ERD data file provides a civil GPS user, post facto, with ERD performance information characterizing the quality of predicted GPS data using the ephemeris and clock parameters contained in subframe 1, 2, and 3 of the navigation message of the transmitting SV.

#### 30.1.3.1 Contents Definition

The contents of ERD data transfer block are defined in Table 30-5 and described in Table 30-6. One block is created and transferred to the CGIC for every TBD Kalman update interval.

#### 30.1.3.2 Usage

This file provides a GPS civil user with MCS determined ERDs versus time.

#### 30.1.3.3 Special Requirements

None

TABLE 30-5

ERD DATA LONG DELAY
TRANSFER FILE DEFINITIONS

| ITEM | DESCRIPTION |
|---|---|
| ERD Dat | |
| For each Geographic loc (up to 32) | Coordinates or pre-selected geographic location for which estimated range deviation has been calculated |
| Geographic loc lat. | Latitude |
| Geographic loc long. | Longitude |
| Geographic loc elevation | Elevation above geoid |
| Time of ERD | GPS time of Kalman update from which current state estimate was obtained, in GPS weeks and seconds of week |
| AOD | Time difference between time of ERD and time of the last measurement update which contriubted to the broadcast ephemeris set used in the ERD; of the form: time of ERD-solution update time |
| For each SV | |
| SV Reference Number | See Section 6.0 |
| ERD from SA contaminated data | Estimated range deviation from data contaminated by selective availability |
| Alarm | Flags, set if either non-SA or SA estimated range deviation exceeds its tolerance threshold |
| Archive Flag | Flag indicating block has been retrieved from ORMS archive<br>0 = block from regular transmission<br>1 = block retrieved from archive |

TABLE 30-6

ERD DATA LONG DELAY
TRANSFER FILE

| ITEM | UNITS/FORMAT | VALUE/RANGE | PRECISION |
|---|---|---|---|
| ERD Data | | | |
| For each Geographic loc (up to 32): | | | |
| Geographic loc lat. | Degrees | N/A | DP |
| Geographic loc long. | Degrees | N/A | DP |
| Geographic loc elevation | Meters | N/A | DP |
| Time of ERD | GPS Time | N/A | DP |
| AOD | Seconds | N/A | DP |
| For each SV | | | |
| SV reference number | Integer | 0-255 | 1 |
| ERD from SA contaminated data | Meters | N/A | DP |
| Alarm | Flag | 0 or 1 | 1 |
| Archive Flag | /Integer | 0-255 | 1 |

### 30.1.4 MS Navigation Solution Block Format

The MS Navigation Solution file provides a civil GPS user, post facto, with MS position information characterizing the quality of GPS monitored data using the ephemeris and clock parameters contained in subframe 1, 2, and 3 of the navigation message of the transmitting SV.

#### 30.1.4.1 Contents Definition

The contents of MS Navigation Solution transfer block are defined in Table 30-7 and described in Table 30-8. One block is created and transferred to the CGIC for every TBD Kalman update interval.

#### 30.1.4.2 Usage

This file provides a GPS civil user with MCS determined monitor station position solutions and the error in those solutions versus time.

#### 30.1.4.3 Special Requirements

None

TABLE 30-7

MS NAVIGATION SOLUTION DATA
LONG DELAY TRANSFER FILE DEFINITIONS

| ITEM | DESCRIPTION |
|---|---|
| MS Navigation Solution Data | |
| For each MS | |
| GS Reference Number | See Section (TBD) |
| Time of NAV solution | GPS time of Kalman interval from which measurements employed in Navigation Solution were obtained, in GPS weeks and seconds of week |
| MS Clock Residual | Offset of monitor station clock from the value obtained from navigation solution |
| SV Reference Number (4 element vector) | See Section 6.0 |
| GDOP | Geometric dilution of precision value for space vehicle set employed |
| Navigation Solution from SA contaminated data | |
| N/S Error | Component, along longitude, of difference between monitor station position and position obtained from navigation solution |
| E/W Error | Component, along latitude, of difference between monitor station position and position obtained from navigation solution |
| Elevation Error | Component, normal to geoid, of difference between monitor station position and position obtained from navigation solution |
| Alarm | Flag, set if any location error exceeds tolerance threshold |
| Archive Flag | Flag indicating block has been retrieved from ORMS archive<br>0 = block from regular transmission<br>1 = block retrieved from archive |

TABLE 30-8

MS NAVIGATION SOLUTION DATA
LONG DELAY TRANSFER FILE

| ITEM | UNITS/FORMAT | VALUE/RANGE | PRECISION |
|---|---|---|---|
| MS Navigation Solution Data | | | |
| For each MS | | | |
| GS Reference Number (MS ID) | Integer | 0-255 | 1 |
| Time of Nav solution | GPS Time | N/A | DP |
| MS Clock residual | Seconds | N/A | DP |
| SV Reference Number (4-element vector) | Integer | 0-255 | 1 |
| GDOP | Numeric | N/A | DP |
| Navigation solution from SA contaminated data | | | |
| N/S error | Meters | N/A | DP |
| E/W error | Meters | N/A | DP |
| Elevation error | Meters | N/A | DP |
| Alarm | Flag | 0/1 | 1 |
| Archive Flag | /Integer | 0-255 | 1 |

### 30.1.5 SV Position and Timing Error Block Format

The SV Position and Timing Error file provides a civil GPS user, post facto, with SV positional information characterizing the quality of the GPS ephemeris and clock parameters contained in subframe 1, 2, and 3 of the navigation message of the transmitting SV.

#### 30.1.5.1 Contents Definition

The contents of the SV Position and Timing Error transfer block are defined in Table 30-9 and described in Table 30-10. One block is created and transferred to the CGIC for every TBD Kalman update interval.

#### 30.1.5.2 Usage

This file provides a GPS civil user with MCS determined SV position and timing variances.

#### 30.1.5.3 Special Requirements

None

TABLE 30-9

SV POSITION AND TIMING ERROR DATA
LONG DELAY TRANSFER FILE DEFINITIONS

| ITEM | DESCRIPTION |
|---|---|
| Position and Timing Error Statistics for each SV | |
| SV Reference Number | See Section 6.0 |
| For each time of 14 day interval | |
| $(sigma)^2_R$ | Variance of SV position prediction error component radial in the orbit plane |
| $(sigma)^2_A$ | Variance of SV position prediction error component nominally tangent to trajectory |
| $(sigma)^2_C$ | Variance of SV position prediction error component perpendicular to the orbit plane |
| $(sigma)^2_T$ | Variance of SV timing prediction error |
| Statistics Update Time | Time of most recent statistics update |
| Archive Flag | Flag indicating block has been retrieved from ORMS archive<br>0 = block from regular transmission<br>1 = block retrieved from archive |

TABLE 30-10

SV POSITION AND TIMING ERROR DATA
LONG DELAY TRANSFER FILE

| ITEM | UNITS/FORMAT | VALUE/RANGE | PRECISION |
|---|---|---|---|
| Position and Timing Error Statistics for each SV: | | | |
| SV Reference Number | /Integer | 0-255 | 1 |
| For each time of 14 day interval | | | |
| $(\text{sigma})^2_R$ | $\text{Meters}^2$ | 0 to $(32768)^2$ | SP |
| $(\text{sigma})^2_A$ | $\text{Meters}^2$ | 0 to $(32768)^2$ | SP |
| $(\text{sigma})^2_C$ | $\text{Meters}^2$ | 0 to $(32768)^2$ | SP |
| $(\text{sigma})^2_T$ | $\text{Meters}^2$ | 0 to $(32768)^2$ | SP |
| Statistics Update Time | GPS time | N/A | DP |
| Archive Flag | /Integer | 0-255 | 1 |

### 30.1.6 Kalman Flag Status Block Format

The Kalman Flag Status file provides a civil GPS user, post facto, with statistics on the Kalman filter performance of a solution using the Kalman estimated ephemeris.

#### 30.1.6.1 Contents Definition

The items in a Kalman Flag Status transfer block are defined in Table 30-11 and identified in Table 30-12. One block is created and transferred to the CGIC for every TBD Kalman update interval.

#### 30.1.6.2 Usage

This file provides Kalman filter status.

#### 30.1.6.3 Special Requirements

None.

TABLE 30-11

KALMAN FLAG STATUS LONG DELAY
TRANSFER FILE DEFINITIONS

| ITEM | DESCRIPTION |
|---|---|
| Kalman update time | GPS time of Kalman update for which states were estimated in GPS week number and seconds of GPS week |
| Reprocess Number | Number of times estimation processing was rerun |
| Estimation Event Flags | Events occurring during this Kalman update interval |
| Archive Flag | Flag indicating block has been retrieved from ORMS archive<br>0 = block from regular transmission<br>1 = block retrieved from archive |

TABLE 30-12

KALMAN FLAG STATUS LONG DELAY TRANSFER FILE

| ITEM | UNITS/FORMAT | VALUE/RANGE | PRECISION |
|---|---|---|---|
| Kalman update time | GPS Time wks<br>secs | $0-2^{10}-1$<br>1-604,800 | 1<br>1.5 |
| Reprocess Number | Integer | 0-255 | 1 |
| Estimation Event Flags | N/A | 16 bits<br>for each bit: | N/A |
| Bit Event | | | |
| 1 Kalman backup | | 0 = No Event | |
| 2 Partition replay | | 1 = Event | |
| 3 Noon turn | | | |
| 4 Stationkeeping Maneuver | | | |
| 5 Momentum dump | | | |
| 6 Z-count/code phase adj | | | |
| 7 Frequency standard change (SV) | | | |
| 8 Frequency standard adjust (SV) | | | |
| 9 Reinitialization | | | |
| 10 Ephemeris epoch time update | | | |
| 11-16 Spare | | | |
| Archive Flag | /Integer | 0-255 | 1 |

### 30.1.7 SV URA Current State Block Format

The Current State file provides a civil GPS user, post facto, with statistics on the Kalman filter performance of a solution using the Kalman estimated ephemeris.

#### 30.1.7.1 Contents Definition

The items in an SV Current State transfer block are defined in Table 30-13 and identified in Table 30-14. One block is created and transferred to the CGIC for every TBD Kalman update interval.

#### 30.1.7.2 Usage

This file provides URA and its components as determined from the MCS Kalman filter's estimated covariance.

#### 30.1.7.3 Special Requirements

None.

TABLE 30-13

SV CURRENT STATE URA LONG DELAY
TRANSFER FILE DEFINITIONS

| ITEM | DESCRIPTION |
|---|---|
| Kalman Update Time | GPS Time of Kalman update for which states were estimated in GPS week number and seconds of GPS week |
| Reprocess Number | Number of times estimation processing was rerun |
| SV Reference Number | See Section 6.0 |
| Archive Flag | Flag indicating block has been retrieved from ORMS archive<br>0 = block from regular transmission<br>1 = block retrieved from archive |
| SV Current State URA, without SA contamination | User range accuracy computed using Kalman solution's covariance matrix. |
| Sigma R | One sigma value of the SV position error component radial in the orbit plane. |
| Sigma A | One sigma value of the SV position error component nominally tangential (along track) to the trajectory. |
| Sigma C | One sigma value of the SV position error component perpendicular to the orbit plane |
| Sigma T | One sigma value of the range error due to SV timing. |
| Sigma P | One sigma value of range error due to encountered and scheduled perturbations (e.g., momentum dumps, eclipse, etc.). |
| Sigma M | RMS range measurement apriori residual based on smoothed (15 minutes) monitor station data. |

TABLE 30-14

SV CURRENT STATE URA LONG DELAY TRANSFER FILE

| ITEM | UNITS/FORMAT | VALUE/RANGE | PRECISION |
|---|---|---|---|
| Kalman update time | GPS Time wks<br>secs | $0\text{-}2^{10}\text{-}1$<br>1-604,800 | 1<br>1.5 |
| Reprocess Number | Integer | 0-255 | 1 |
| SV Reference Number | Integer | 0-255 | 1 |
| Archive Flag | /Integer | 0-255 | 1 |
| SV Current State URA, without SA Contamination | Integer | 1-32 | 1 |
| Sigma R | Meters | N/A | DP |
| Sigma A | Meters | N/A | DP |
| Sigma C | Meters | N/A | DP |
| Sigma T | Meters | N/A | DP |
| Sigma P | Meters | N/A | DP |
| Sigma M | Meters | N/A | DP |

### 30.1.8 Long Delay S/S/W Message Block Format

The Long Delay S/S/W Message file provides the Civil GPS user, post facto, with information as to various changes in navigational status of the space vehicles, the master control station (especially in regards to filter operations), and the master clock. Changes in status of these GPS subsystems are indicated by S/S/W messages and their contained parameter(s).

#### 30.1.8.1 Contents Definition

Long Delay S/S/W Messages consists of those A/W/E messages that will be transmitted after a long delay to the CGIC as postprocessed information. Other than the difference in transfer delay to the CGIC, Long Delay S/S/W Messages have the same definition and format as the short delayed advisory blocks S/S/W message described in Section 10.2.

#### 30.1.8.2 Usage

This file provides a GPS civil user with status information relating to several status changes including:

SV clock changes, status, z-adjusts, orbit adjusts, momentum dumps, filter operations, filter restarts, master clock changes, and the exceeding of tolerances by filter and clock performance parameters.

#### 30.1.8.3 Special Requirements

None.

### 30.1.9 Global SV Transmit and Upload Schedule Block Format

The Global SV Transmit and Upload file provides a civil GPS user, post facto, with a global schedule of the navigation message pages transmit and upload times.

#### 30.1.9.1 Contents Definition

The contents of a Global SV Transmit and Upload transfer block are defined in Table 30-15 and identified in Table 30-16. A separate transfer block is associated with all navigation message pages that begin transmission during a single GPS defined day. The multiple NAV message page entries in a given transfer block are ordered by increasing beginning-of-transmit times.

#### 30.1.9.2 Usage

This file provides information to a CGIC database which will allow users to perform quick searches regarding changes in NAV message broadcasts over SVs, pages, broadcast intervals, or upload times.

#### 30.1.9.3 Special Requirements

None.

TABLE 30-15

GLOBAL SV TRANSMIT AND UPLOAD LONG DELAY
TRANSFER FILE DEFINITIONS

| ITEM | DESCRIPTION |
|---|---|
| Day of Year | Beginning day of year of this transfer block |
| GPS Week Number | GPS week number corresponding to block's beginning day of year |
| Archive Flag | Flag indicating block has been retrieved from ORMS archive<br>0 = block from regular transmission<br>1 = block retrieved from archive |
| Vectors sequenced by beginning of transmission: | |
| Beginning of Transmission | Time, in seconds of week, when navigation message element began transmission; all beginning times occur within the interval spanned by the block's day of year. |
| Ending of Transmission | Time, in seconds of week, when navigation message element ended transmission, seconds of week referenced to GPS week of transmission |
| Transmitting SV PRN Reference Number | SV PRN of transmitting SV |
| Time of Upload | Time, in seconds of week, when navigation message element was uploaded to SV, seconds of week referenced to GPS week number |
| Subframe Number | Subframe number of navigation message element identified by transmit times, valid entries are:<br>1,2,3,4,5, or<br>E if subframes 1, 2, 3 have the same beginning transmission times within TBD seconds, or<br>A if all almanac pages have the same beginning transmission time within TBD seconds; where almanac pages are defined to be pages 1-24 of subframe 5, and pages 2-5 and 7-10 of subframe 4 subframe 4 |

| | |
|---|---|
| **Page Number** | Page number of navigation message element corresponding to transmit times, will be zero for subframes 1 through 3 and 5 for 'A' |
| **Reference SV PRN Number** | Navigation message element's reference SV PRN number, when subframe number is an 'A' value, the reference SV PRN number is 0 |
| **Age of NAV Information** | Age, measured in seconds, between the last information used in determining a NAV message page and the beginning of transmission of that page |

TABLE 30-16

GLOBAL SV TRANSMIT AND UPLOAD LONG DELAY
TRANSFER FILE

(TO BE DETERMINED)

### 30.1.10 Navigation Data Error Summary Block Format

The Navigation Data Error Summary file contains information which identifies the NAV message data received from monitor stations which failed the OCSs navigation verification test, i.e., did not successfully compare to the predicted data from the navigation upload.

#### 30.1.10.1 Contents Definition

The items in a Navigation Data Error Summary transfer block are defined in Table 30-17 and identified in Table 30-18. Blocks are transferred at least every TBD days to the CGS.

#### 30.1.10.2 Usage

This file provides a summary of the results of the OCS's navigation verification testing. The user of this information should be aware that the set of all NAV message broadcasts are not continuously verified due to non-visibility, availability, or allocation of resources. For this data transfer block type, navigation verification failure intervals are defined as two or more successive verification failures, each differing in time by less than 1 min. Isolated failures, which may be spurious, are indicated by the same beginning and ending times.

#### 30.1.10.3 Special Requirements

None

TABLE 30-17

NAVIGATION DATA ERROR SUMMARY LONG DELAY
TRANSFER FILE DEFINITIONS

| ITEM | DESCRIPTION |
|---|---|
| Block Index | Block index of navigation data error summary transfer block, TBD |
| SV Reference Number | See Section 6.0 |
| Archive Flag | Flag indicating block has been retrieved from ORMS archive<br>0 = block from regular transmission<br>1 = block retrieved from archive |
| Beginning Time of Verification Failure GPS Week, Seconds of Week | Time of the navigation data from the HOW word |
| Ending Time of Verification Failure GPS Week, Seconds of Week | Time of the navigation data from the HOW word |
| Affected Subframe Number | Subframe (1-5) of the navigation data which failed verification test |
| Affected Page Number | Subframe (1-25) of the navigation data which failed verification test--valid only for subframe 4 and 5 |

TABLE 30-18

NAVIGATION DATA ERROR SUMMARY LONG DELAY TRANSFER FILE

| ITEM | UNITS/FORMAT | VALUE/RANGE | PRECISION |
|---|---|---|---|
| Block Index | /Integer | TBD | 1 |
| SV Reference Number | /Integer | 0 - 255 | 1 |
| Archive Flag | /Integer | 0 - 255 | 1 |
| Beginning Time of Verification Failure | | | |
| GPS Week | Weeks/Integer | 0 to 1023 | 1 |
| Seconds of Week | Seconds of GPS Week/Real | 0 - 604798.5 | 1.5 |
| Ending Time of Verification Failure | | | |
| GPS Week | Weeks/Integer | 0 to 1023 | 1 |
| Seconds of Week | Seconds of GPS Week/Real | 0 - 604798.5 | 1.5 |
| Affected Subframe Number | /Integer | 1 - 5 | 1 |
| Affected Page Number | /Integer | 1 - 25 | 1 |

## 30.2 Ephemeris Information

### 30.2.1 SV Kalman Estimated Ephemeris Block Format

The SV Kalman Estimated Ephemeris provides a civil GPS user, post facto, with SV ephemerides as determined by the MCS filter. This postprocessed ephemeris information is referred to as the Kalman estimated ephemeris.

#### 30.2.1.1 Contents Definition

The contents in an SV ephemeris transfer block are defined in Table 30-19 and described in Table 30-20. A single file block is generated for all SVs being currently estimated by all Kalman partitions. A new block is transmitted to the CGIC for every TBD filter update interval.

#### 30.2.1.2 Usage

This file provides the current state estimates of the SV states as determined by the MCS Kalman filter. It includes the Kalman's position, velocity, clock, and covariance estimates.

#### 30.2.1.3 Special Requirements

None.

TABLE 30-19

KALMAN ESTIMATED SV EPHEMERIS LONG DELAY
TRANSFER FILE DEFINITIONS

| ITEM | DESCRIPTION |
|---|---|
| Kalman Update Time | GPS time of Kalman update for which states were estimated |
| GPS Week Number<br>Seconds of GPS Week | |
| Bulletin Number | Identification of USNO bulletin which is the source of polar motion and time prediction parameters used in estimation |
| Reprocess Number | Number of times estimation processing was rerun |
| Archive Flag | Flag indicating block has been retrieved from ORMS archive<br>0 = block from regular transmission<br>1 = block retrieved from archive |
| Vector of SV PRN Numbers | See Section 6.0 |
| Vector of SV Reference Numbers | *Section Section 6.0* |
| For each SV: | |
| Estimation Event Flags | Flags describing events occurring during Kalman update interval |
| Kalman current state vector | Vector of SV current state estimates for partition |
| $R_x$ | x-component of space vehicle position represented in Earth-centered inertial coordinate system |
| $R_y$ | y-component of space vehicle position represented in Earth-centered inertial coordinate system |
| $R_z$ | z-component of space vehicle position represented in earth-centered inertial coordinate system. |
| $V_x$ | x-component of space vehicle velocity represented in Earth-centered inertial coordinate system |
| $V_y$ | y-component of space vehicle velocity represented in Earth-centered inertial coordinate system |

| | |
|---|---|
| $V_z$ | z-component of space vehicle velocity represented in earth-centered inertial coordinate system |
| K1 solar pressure scaling parameter | Solar pressure scaling parameter along sunline unitless) |
| K2 solar pressure acceleration parameter | Solar pressure acceleration parameter along space vehicle body y-axis |
| SV clock bias | Current state for space vehicle clock bias |
| SV clock drift | Current state for space vehicle clock drift |
| SV clock drift rate | Current state for space vehicle clock drift rate |
| Covariance matrix of current state in U-D factored form. | U is upper right triangular unitary matrix. D elements are stored along diagonal, replacing redundant 1's. Units are derived from those of epoch state residuals. |

TABLE 30-20

KALMAN ESTIMATED SV EPHEMERIS LONG DELAY TRANSFER FILE

| ITEM | UNITS/FORMAT | VALUE/RANGE | PRECISION |
|---|---|---|---|
| Kalman update time | | | |
| GPS Week Number | Weeks | $0\text{-}2^{10}$ | 1 |
| Seconds of GPS Week | Secs | 0-604,800 | 1.5 |
| Bulletin Number | Integer | 1-65,536 | 1 |
| Reprocess Number | Integer | 0-255 | 1 |
| Archive Flag | /Integer | 0-255 | 1 |
| Vector of SV PRN Numbers | Integer | 0-37 | 1 |
| Vector of SV Reference Numbers | Integer | 0-255 | 1 |
| For each SV: | | | |
| Estimation Event Flags | N/A | 16 bits for each bit: | N/A |

| Bit | Event | |
|---|---|---|
| 1 | Kalman backup | 0 = No Event |
| 2 | Partition replay | 1 = Event |
| 3 | Noon turn | |
| 4 | Stationkeeping Maneuver | |
| 5 | Momentum dump | |
| 6 | Z-count/code phase adj | |
| 7 | Frequency standard change (SV) | |
| 8 | Frequency standard adjust (SV) | |
| 9 | Reinitialization | |
| 10 | Ephemeris epoch time update | |
| 11-16 | Spare | |

| | | | |
|---|---|---|---|
| Kalman SV Current State Vector | Integer | 1-32 | 1 |
| $R_x$ | Meters | 0 to 26700000 | DP |
| $R_y$ | Meters | 0 to 26700000 | DP |
| $R_z$ | Meters | 0 to 26700000 | DP |
| $V_x$ | Meters/Sec | 0 to 4 X $10^3$ | DP |
| $V_y$ | Meters/Sec | 0 to 4 X $10^3$ | DP |
| $V_z$ | Meters/Sec | 0 to 4 X $10^3$ | DP |
| K1 solar pressure scaling parameter | None | N/A | DP |
| K2 solar pressure acceleration parameter | Meters/$Sec^2$ | N/A | DP |
| SV clock bias | sec | N/A | DP |
| SV clock drift | sec/sec | N/A | DP |
| SV clock drift rate | $sec/sec^2$ | N/A | DP |
| Covariance matrix of epoch state residual in U-D factored form. U is upper right triangular unitary matrix. D elements are stored along diagonal, replacing redundant 1's. Units are derived from those of epoch state residuals. | | | |

## 30.3 GPS Clock Information

### 30.3.1 SV/MC Time Steer Parameter Block Format

The SV/MC Time Steer Parameters file provides a Civil GPS user, in a post facto manner, with a priori and predictive parameters associated with the steering of an SV or the reference clock standard.

#### 30.3.1.1 Contents Definition

The contents in an SV/MC Time Steer Parameters transfer block are defined in Table 30-21 (TBD) and identified in Table 30-22. A separate transfer block is associated with each individual clock standard, and is generated for each clock steer initiated.

#### 30.3.1.2 Usage

This file provides times and parameters characterizing the implementation of a clock standard steering and other continuous or ongoing clock adjustments.

#### 30.3.1.3 Special Requirements

None.

TABLE 30-21

SV/MC TIME STEER PARAMETERS LONG DELAY
TRANSFER FILE DEFINITIONS

(TO BE DETERMINED)

TABLE 30-22

SV/MC TIME STEER PARAMETERS LONG DELAY TRANSFER FILE

| ITEM | UNITS/FORMAT | VALUE/RANGE | PRECISION |
|---|---|---|---|
| Time Steering Initiated | | | |
| GPS Week Number | Weeks | $0\text{-}2^{10}$ | 1 |
| Seconds of GPS Week | Seconds | 0-604,800 | 1.5 |
| Archive Flag | /Integer | 0-255 | 1 |
| Clock Residence<br>0=SV, 1=MS | I | 0 or 1 | N/A |
| SV ID | I | 0-255 | N/A |
| MS ID | I | 1-63 | N/A |
| Directive Code | N/A | 0221 | 1 |
| Directive ID | N/A | 1-TBD | 1 |
| Current Epoch States | N/A | N/A | N/A |
| Time System Reference<br>0=UTC<br>1=GPS | | | |
| Bias parameter | Seconds<br>Real | -1 to +1 | N/A |
| Drift parameter | Seconds/<br>Second<br>Real | $-10^{-9}$ to<br>$+10^{-9}$ | N/A |
| Drift rate parameter | Seconds/<br>$\text{Second}^2$<br>Real | $-10^{-18}$<br>to<br>$+10^{-18}$ | N/A |
| Epoch State Reference Time<br>GPS Week Number | Weeks | 0 to $2^{10}-1$ | 1 |
| Seconds of GPS Week | Seconds | 0 to 604798.5 | 1.5 |

| | | | |
|---|---|---|---|
| Clock Update<br>Effective Time<br>Option | N/A | 0-1 | 1 |
| 0=Subsequent to last K-point | | | |
| 1=Subsequent to specified time | | | |
| Modification Type | I | 0-3 | N/A |
| 0=reference states and residuals (values) | | | |
| 1=reference states only (value) | | | |
| 2=reference states and residuals (increment) | | | |
| 3=references states only (increment) | | | |
| Steering Parameters | | | |
| Beginning Time of Steer | | | |
| Ending Time of Steer | | | |
| Duration of Steer | | | |
| Rate of Steer | | | |
| Target Closure Time | | | |
| Estimated Clock State at End of Steer | | | |
| Time System Reference | | | |
| 0=UTC | | | |
| 1=GPS | | | |

| | | | |
|---|---|---|---|
| Bias parameter | Seconds<br>Real | -1 to +1 | N/A |
| Drift parameter | Seconds/<br>Second<br>Real | $-10^{-9}$ to<br>$+10^{-9}$ | N/A |
| Drift rate parameter | Seconds/<br>Second$^2$<br>Real | $-10^{-18}$<br>to<br>$+10^{-18}$ | N/A |
| Epoch State Reference Time | | | |
| GPS Week Number | Weeks | 0 to $2^{10}-1$ | 1 |
| Seconds of GPS Week | Seconds | 0 to 604798.5 | 1.5 |

### 30.3.2 SV/MS Clock Adjustment Parameter Block Format

The SV/MS Clock Adjustment Parameters file provides a Civil GPS user, post facto, with information characterizing instantaneous or step function adjustments in the space craft vehicle or monitoring station clock references.

#### 30.3.2.1 Contents Definition

The contents in an SV/MS Clock Adjustment transfer block are defined in Table 30-23 and identified in Table 30-24. An individual transfer block is associated with a single time tag. If several SV or MS clock adjustments occur essentially simultaneously, that is, within a time interval of TBS seconds, then all adjustment parameters are included in a single transfer block. The frequency of generation of transfer blocks is one for each clock's adjustment, unless adjustments are implemented simultaneously as defined previously.

#### 30.3.2.2 Usage

This file provides times and parameters characterizing the following:

- adjustment of the epoch states of the clock offset models of the operational SV and MS clock,
- adjustment of the reference clock epoch states,
- MS station time change generation,
- MS station time change correction,
- MS frequency standard change,
- PRN code phase/Z-count adjust computation, and
- other SV clock adjusts.

#### 30.3.2.3 Special Requirements

None.

TABLE 30-23

SV/MS CLOCK ADJUSTMENT PARAMETERS LONG DELAY
TRANSFER FILE DEFINITIONS

| ITEM | DEFINITIONS |
|---|---|
| Archive Flag | Flag indicating block has been retrieved from ORMS archive<br>0 = block from regular transmission<br>1 = block retrieved from archive |
| Reference Clock Parameters | |
| -Designation | |
| GS Reference Number | See Section TBD |
| Time of Designation | GPS Time of designation of this monitor station clock as reference |
| -State | |
| Bias | Offset of reference clock from GPS time at update time |
| Drift | Rate of change of reference clock time with respect to GPS Time at update time |
| Time of last update | Update time for Reference Clock bias and drift |
| -Deviation from MS Clocks | |
| Time of Kalman Update | GPS Time of monitor station clock state residual estimation |
| GS Reference Number | See Section TBD |
| Reference-MS Clock | Difference between reference clock and monitor Station clock |
| -Deviation from Mean Time | |
| Time of Kalman Update | GPS Time of monitor station clock state residual estimation |
| MS Clock Weights | Weighting employed in computation of mean time |
| Mean Time Scale | Time calculated for monitor station clock ensemble |
| Reference Clock-Mean time | Difference between reference clock time and calculated ensemble time |
| Deviation | Difference between reference clock time and calculated ensemble time |

| | |
|---|---|
| Drift | Drift between reference clock time and calculated ensemble time |
| MS Clock Parameters<br>GS Reference Number | See Section TBD |
| -ID of Operational Clock | Identifies primary frequency standard or backup frequency standard as current operation clock |
| -Time of Designation of Operational Clock | GPS time when current operational clock was designated |
| -Phase Difference between Operational and Backup | |
| Bias | Phase offset estimate of backup frequency standard from operational frequency standard at reference time |
| Drift | Rate of change of phase offset estimate of backup frequency standard from operational frequency standard at reference time |
| *Reference Time* | *Reference time for bias and drift values* |
| Time of Last Update | GPS Time of last measurement used in estimation of bias and drift |
| Estimation Interval | Time interval spanned by measurements used in estimation of bias and drift |
| -Allan Variance of Kalman Estimates | |
| Allan Variance | Allan variance of the Kalman estimates of the monitor station clock states. |
| Delay | Interval between residual estimate samples employed in computation |
| Time of Kalman Update | GPS Time of Monitor Station Clock state residual estimates employed |
| -Station Time Change Parameters | |
| Increment/Decrement to TOW | Number of 1.5 seconds intervals to increment/decrement time of week |

| | |
|---|---|
| P-code adjustment | P-code adjustment expressed as number of chips |
| Time of Generation | GPS time of generation of monitor station time change parameters |
| SV Clock Parameters<br>SV Reference Number | See Section TBD |
| -ID of Operational Standard | Identifies clock currently serving as operational clock |
| -Time of Designation of Operational Standard | GPS time when use of current operational standard was initiated |
| -C-field Adjust<br>Time of Adjust | GPS time for execution of C-field adjust |
| Magnitude of Adjust | Magnitude of C-field adjustment |
| -Z Count Adjust<br>Adjust Time | GPS time, coincident with navigation frame boundary, for adjustment |
| Magnitude of Adjust | Adjustment, expressed as integer number of P-code chips |
| Command Word | z-count adjust command |
| Verification Flag | Flag, set upon notification of occurrence of adjust |
| -Allan Variance of Kalman Estimate<br>Time of Kalman Update | GPS Time of Kalman update from which epoch state residual estimates were obtained |
| Allan Variances | Allan variance of the Kalman state estimates of the space vehicle clock |
| Delays | Interval between residual estimate samples employed in computation |
| Clock Offset Models<br>-For each SV<br>SV Reference Number | See section TBD |
| Reference time | Reference time for SV clock offset model |

| | |
|---|---|
| Polynomial coefficients<br>$A_0$<br>$A_1$<br>$A_2$ | SV clock offset model |
| -For each MS | |
| GS Reference Number | See Section TBD |
| Reference time | Reference time for MS clock offset model |
| Polynomial Coefficients<br>$A_0$<br>$A_1$ | MS clock offset model |

TABLE 30-24

SV/MS CLOCK ADJUSTMENT PARAMETERS LONG DELAY TRANSFER FILE

| ITEM | UNITS/FORMAT | VALUE/RANGE | PRECISION |
|---|---|---|---|
| Archive Flag | /Integer | 0-255 | 1 |
| Reference Clock Parameters -Designation | | | |
| GS Reference Number (MS ID) | Integer | 0-255 | 1 |
| Time of Designation | GPS Time weeks | $0-2^{10}$ | 1 |
| | secs | 0-604,800 | 1.5 |
| -State | | | |
| Bias | Seconds | N/A | DP |
| Drift | sec/sec | N/A | DP |
| Time of last update | GPS Time weeks | $0-2^{10}$ | 1 |
| | secs | 0-604,800 | 1.5 |
| -Deviation from MS Clocks | | | |
| Time of Kalman Update | GPS Time weeks | $0-2^{10}$ | 1 |
| | secs | 0-604,800 | 1.5 |
| GS Reference Number (MS ID) | Integer | 0-255 | 1 |
| Reference-MS Clock | Seconds | N/A | DP |
| -Deviation from Mean Time Time of Kalman Update | GPS Time weeks | $0-2^{10}$ | 1 |
| | secs | 0-604,800 | 1.5 |
| MS Clock Weights | Dimensionless | 0-1 | 0.05 |
| Mean Time Scale | Seconds | N/A | DP |
| Reference Clock- Mean Time | Seconds | N/A | DP |
| Deviation | Seconds | N/A | DP |

| | | | |
|---|---|---|---|
| Drift | Femtoseconds/ Seconds | N/A | DP |
| MS Clock Parameters | | | |
| GS Reference Number (MS ID) | Integer | 0-255 | 1 |
| -ID of Operational Clock | Count | 1-2 | 1 |
| -Time of Designation of Operational Clock | GPS Time weeks<br>secs | $0\text{-}2^{10}$<br>0-604,800 | 1<br>1.5 |
| -Phase Difference between Operational and Backup | | | |
| Bias | Radians | N/A | DP |
| Drift | Radians/sec | N/A | DP |
| Reference Time | GPS Time weeks<br>secs | $0\text{-}2^{10}$<br>0-604,800 | 1<br>1.5 |
| Time of Last Update | GPS Time weeks<br>secs | $0\text{-}2^{10}$<br>0-604,800 | 1<br>1.5 |
| Estimation Interval | Seconds | N/A | DP |
| -Allan Variance of Kalman Estimates | | | |
| Allan Variance | Dimensionless | N/A | DP |
| Delay | Seconds | N/A | DP |
| Time of Kalman Update | GPS time weeks<br>secs | $0\text{-}2^{10}$<br>0-604,800 | 1<br>1.5 |
| -Station Time Change Parameters | | | |
| Increment/Decrement to TOW | Seconds | +/-604,800 | 1.5 |
| p-code adjustment | Integer | -1432215 to +15344998 | 1 chip |
| Time of Generation | GPS Time weeks<br>secs | $0\text{-}2^{10}$<br>0-604,800 | 1<br>1.5 |

| | | | |
|---|---|---|---|
| SV Clock Parameters<br>SV Reference Number | Integer | 1-255 | 1 |
| -ID of Operational Standard | Count | 1-4 | 1 |
| Time of Designation of Operational Standard | GPS Time weeks<br>secs | $0-2^{10}$<br>0-604,800 | 1<br>1.5 |
| -C-field Adjust<br>Time of Adjust | GPS Time weeks<br>Secs | $0-2^{10}$<br>0-604,800 | 1<br>1.5 |
| Magnitude of Adjust | A/R | A/R | A/R |
| -Z Count Adjust<br>Adjust Time | GPS Time weeks<br>secs | $0-2^{10}$<br>0-604,800 | 1<br>1.5 |
| Magnitude of Adjust | Sec | 0-604,800 | 97.75 x 10 |
| Command Word | Character | 88-bit word | N/A |
| Verification Flag | N/A | 0/1 | 1 |
| -Allan Variance of Kalman Estimates<br>Time of Kalman Update | GPS Time weeks<br>Secs | $0-2^{10}$<br>0-604,800 | 1<br>1.5 |
| Allan Variance | dimensionless | N/A | DP |
| Delays | Seconds | N/A | DP |
| Clock Offset Models<br>-For each SV:<br>SV Reference Number | Integer | 1-255 | 1 |
| Reference Time | GPS Time weeks<br>secs | $0-2^{10}$<br>0-604,800 | 1<br>1.5 |
| Polynominal coefficients<br>$A_0$<br>$A_1$<br>$A_2$ | <br>Seconds<br>Sec/sec<br>Sec/sec$^2$ | <br>N/A<br>N/A<br>N/A | <br>DP<br>DP<br>DP |

| | | | |
|---|---|---|---|
| -For each MS: | | | |
| GA Reference Number (MS ID) | Integer | 0-255 | 1 |
| Reference time | GPS Time weeks | $0\text{-}2^{10}$ | 1 |
| | secs | 0-604,800 | 1.5 |
| Polynomial Coefficients | | | |
| $A_0$ | Seconds | N/A | DP |
| $A_1$ | Sec/sec | N/A | DP |

### 30.3.3 SV/MS Clock Calibration Block Format

The SV/MS Clock Calibration file provides a civil GPS user, post facto, with information characterizing SV/MS clock epoch states as well as frequency standards and stabilities as functions of GPS time.

#### 30.3.3.1 Contents Definition

The contents in an SV/MS Clock Calibration transfer block are defined in Table 30-25 and identified in Table 30-26. A file block contains information automatically computed for each Kalman update interval; a file block is generated every TBD Kalman intervals for SV parameters and every TBD for MS parameters.

#### 30.3.3.2 Usage

This file provides calibration parameters characterizing the following.

- current time clock polynominals which represent the deviation of the SV operational clocks from GPS time
- the relative bias and drift of the phase difference between the operational and backup frequency standards at each monitor station
- the Allan variance of the Kalman estimates of the MS clock states as an indicator of the relative health of the MS clocks
- Allan variance of the Kalman estimates of the SV clock states

#### 30.3.3.3 Special Requirements

None.

TABLE 30-25

SV/MS CLOCK CALIBRATION BLOCK FORMAT
LONG DELAY TRANSFER FILE DEFINITIONS

| ITEM | DEFINITIONS |
|---|---|
| Archive Flag | Flag indicating block has been retrieved from ORMS archive<br>0 = block from regular transmission<br>1 = block retrieved from archive |
| MS Clock Parameters<br>GS Reference Number | See Section TBD |
| -ID of Operational Clock | Identifies primary frequency standard or backup frequency standard as current operation clock |
| -Time of Designation of Operational Clock | GPS time when current operational clock was designated |
| -Phase Difference between Operational and Backup | |
| Bias | Phase offset estimate of backup frequency standard from operational frequency standard at reference time |
| Drift | Rate of change of phase offset estimate of backup frequency standard from operational frequency standard at reference time |
| Reference Time | Reference time for bias and drift values |
| Time of Last Update | GPS time of last measurement used in estimation of bias and drift |
| Estimation Interval | Time interval spanned by measurements used in estimation of bias and drift |
| -Allan Variance of Kalman Estimates | |
| Allan Variance | Allan variance of the Kalman estimates of the monitor station clock states. |
| Delay | Interval between residual estimate samples employed in computation |
| Time of Kalman Update | GPS time of monitor station clock state residual estimates employed |

| | |
|---|---|
| -Station Time Change Parameters | |
| Increment/Decrement to TOW | Number of 1.5 seconds intervals to increment/decrement time of week |
| P-code adjustment | P-code adjustment expressed as number of chips |
| Time of Generation | GPS time of generation of monitor station time change parameters |
| SV Clock Parameters | |
| SV Reference Number | See Section TBD |
| -ID of Operational Standard | Identifies clock currently serving as operational clock |
| -Time of Designation of Operational Standard | GPS time when use of current operational standard was initiated |
| -C-field Adjust | |
| Time of Adjust | GPS time for execution of C-field adjust |
| Magnitude of Adjust | Magnitude of C-field adjustment |
| -Z Count Adjust | |
| Adjust Time | GPS time, coincident with navigation frame boundary, for adjustment |
| Magnitude of Adjust | Adjustment, expressed as integer number of P-code chips |
| Command Word | z-count adjust command |
| Verification Flag | Flag, set upon notification of occurrence of adjust |
| -Allan Variance of Kalman Estimate | |
| Time of Kalman Update | GPS time of Kalman update from which epoch state residual estimates were obtained |
| Allan Variances | Allan variance of the Kalman state estimates of the space vehicle clock |
| Delays | Interval between residual estimate samples employed in computation |

| | |
|---|---|
| Clock Offset Models | |
| -For each SV | |
| SV Reference Number | See section 6.0 |
| Reference time | Reference time for SV clock offset model |
| Polynomial coefficients | SV clock offset model |
| $A_0$ | |
| $A_1$ | |
| $A_2$ | |
| -For each MS | |
| GS Reference Number | See Section TBD |
| Reference time | Reference time for MS clock offset model |
| Polynomial Coefficients | MS clock offset model |
| $A_0$ | |
| $A_1$ | |

TABLE 30-26

SV/MS CLOCK CALIBRATION BLOCK FORMAT
LONG DELAY TRANSFER FILE

| ITEM | UNITS/FORMAT | VALUE/RANGE | PRECISION |
|---|---|---|---|
| Archive Flag | /Integer | 0-255 | 1 |
| MS Clock Parameters | | | |
| GS Reference Number (MS ID) | Integer | 0-255 | 1 |
| -ID of Operational Clock | Count | 1-2 | 1 |
| -Time of Designation of Operational Clock | GPS Time weeks | $0-2^{10}$ | 1 |
| | secs | 0-604,800 | 1.5 |
| -Phase Difference between Operational and Backup | | | |
| Bias | Radians | N/A | DP |
| Drift | Radians/sec | N/A | DP |
| Reference Time | GPS Time weeks | $0-2^{10}$ | 1 |
| | secs | 0-604,800 | 1.5 |
| Time of Last Update | GPS Time weeks | $0-2^{10}$ | 1 |
| | secs | 0-604,800 | 1.5 |
| Estimation Interval | Seconds | N/A | DP |
| -Allan Variance of Kalman Estimates | | | |
| Allan Variance | dimensionless | N/A | DP |
| Delay | Seconds | N/A | DP |
| Time of Kalman Update | GPS time weeks | $0-2^{10}$ | 1 |
| | secs | 0-604,800 | 1.5 |
| -Station Time Change Parameters | | | |
| Increment/Decrement to TOW | Seconds | +/-604,800 | 1.5 |

| | | | |
|---|---|---|---|
| P-code adjustment | Integer | -1432215 to +15344998 | 1 chip |
| Time of Generation | GPS Time weeks<br>secs | $0\text{-}2^{10}$<br>0-604,800 | 1<br>1.5 |
| SV Clock Parameters<br>SV Reference Number | Integer | 1-255 | 1 |
| -ID of Operational Standard | Count | 1-4 | 1 |
| -Time of Designation of Operational Standard | GPS Time weeks<br>secs | $0\text{-}2^{10}$<br>0-604,800 | 1<br>1.5 |
| -C-field Adjust<br>Time of Adjust | GPS Time weeks<br>Secs | $0\text{-}2^{10}$<br>0-604,800 | 1<br>1.5 |
| Magnitude of Adjust | A/R | A/R | A/R |
| -Z Count Adjust<br>Adjust Time | GPS Time weeks<br>secs | $0\text{-}2^{10}$<br>0-604,800 | 1<br>1.5 |
| Magnitude of Adjust | Sec | 0-604,800 | 97.75 X 10 |
| Command Word | Character | 88-bit word | N/A |
| Verification Flag | N/A | 0/1 | 1 |
| -Allan Variance of Kalman Estimates<br>Time of Kalman Update | GPS Time weeks<br>Secs | $0\text{-}2^{10}$<br>0-604,800 | 1<br>1.5 |
| Allan Variance | dimensionless | N/A | DP |
| Delays | Seconds | N/A | DP |
| Clock Offset Models<br>-For each SV:<br>SV Reference Number | Integer | 1-255 | 1 |

| | | | |
|---|---|---|---|
| Reference Time | GPS Time weeks | $0\text{-}2^{10}$ | 1 |
| | secs | 0-604,800 | 1.5 |
| Polynominal coefficients | | | |
| $A_0$ | Seconds | N/A | DP |
| $A_1$ | Sec/sec | N/A | DP |
| $A_2$ | $Sec/sec^2$ | N/A | DP |
| -For each MS: | | | |
| GA Reference Number (MS ID) | Integer | 0-255 | 1 |
| Reference time | GPS Time weeks | $0\text{-}2^{10}$ | 1 |
| | secs | 0-604,800 | 1.5 |
| Polynomial Coefficients | | | |
| $A_0$ | Seconds | N/A | DP |
| $A_1$ | Sec/sec | N/A | DP |

### 30.3.4 GPS-UTC Coordination Block Format

The GPS-UTC Coordination file provides a civil GPS user, post facto, with information characterizing the difference between GPS time and UTC and the coordination of that GPS time to the MS clock ensemble and a mean time scale.

#### 30.3.4.1 Contents Definition

The contents in a GPS-UTC Coordination transfer block are defined in Table 30-27 and identified in Table 30-28. A transfer block contains information automatically computed for each Kalman update interval; a file transfer block is generated every TBD Kalman interval.

#### 30.3.4.2 Usage

This file provides parameters characterizing the following.

- bias and drift of GPS time relative to UTC
- difference between GPS time, as determined by the reference clock, and a MS clock ensemble calculated from a weighted average of the other MS clocks
- estimate of differences between the reference clock and a mean time scale derived from other operational MS clocks.
- designation of the Reference Clock
- update of leap second count

#### 30.3.4.3 Special Requirements

None.

TABLE 30-27

GPS-UTC COORDINATION BLOCK FORMAT
LONG DELAY TRANSFER FILE DEFINITIONS

| ITEM | DESCRIPTION |
|---|---|
| Archive Flag | Flag indicating block has been retrieved from ORMS archive<br>0 = block from regular transmission<br>1 = block retrieved from archive |
| UTC/GPS Time Difference | |
| Time of most recent measurement | GPS time of most recent measurement employed in calculating model parameters |
| Bias Estimate | Offset of GPS time from UTC (USNO) at reference time |
| Drift Estimate | Rate of change of GPS time offset from UTC (USNO) at reference time |
| Reference Time | Reference time for bias and drift estimate |
| Variance of Bias | Variance of bias coefficient estimate at reference time |
| Variance of Drift | Variance of drift coefficient estimate at reference time |
| Reference Clock Parameters | |
| -Designation | |
| GS Reference Number | See Section TBD |
| Time of Designation | GPS time of designation of this monitor station clock as reference |
| -State | |
| Bias | Offset of reference clock from GPS time at update time |
| Drift | Rate of change of reference clock time with respect to GPS Time at update time |
| Time of last update | Update time for reference clock bias and drift |

| | |
|---|---|
| -Deviation from MS Clocks | |
| Time of Kalman Update | GPS time of monitor station clock state residual estimation |
| GS Reference Number | See Section TBD |
| Reference-MS Clock | Difference between reference clock and monitor station clock |
| -Deviation from Mean Time | |
| Time of Kalman Update | GPS time of monitor station clock state residual estimation |
| MS Clock Weights | Weighting employed in computation of mean time |
| Mean Time Scale | Time calculated for monitor station clock ensemble |
| Reference Clock-Mean time | Difference between reference clock time and calculated ensemble time |
| Deviation | Difference between reference clock time and calculated ensemble time |
| Drift | Drift between reference clock time and calculated ensemble time |
| SV Ensemble Allan Variance of Kalman Estimates | |
| -Allan Variancees | Allan variance of the Kalman state estimates of the ensemble clock |
| Delays | Interval between residual estimate samples employed in computation |
| Navigation Data Message Parameters | |
| $A_0$ | Bias between GPS time and UTC |
| $A_1$ | Drift between GPS time and UTC |
| Reference time-of-day | Reference time-of-day for GPS time to UTC relationship |
| Reference time week number | Reference week number for GPS time to UTC relationship |

| | |
|---|---|
| Current Leap Second Count | |
| Count | Number of leap-seconds in UTC (USNO) |
| Effective Date-Time | GPS time of leap-second update |
| Leap Second Advisory Data | |
| -Delta time due to leap seconds | |
| -Number of week effective | |
| -Number of day effective | |
| Clock Offset Models | |
| -For each SV | |
| SV Reference Number | See section TBD |
| Reference time | Reference time for SV clock offset model |
| Polynomial coefficients $A_0$ $A_1$ $A_2$ | SV clock offset model |
| -For each MS | |
| GS Reference Number | See Section TBD |
| Reference time | Reference time for MS clock offset model |
| Polynomial Coefficients $A_0$ $A_1$ | MS clock offset model |

TABLE 30-28

GPS-UTC COORDINATION BLOCK FORMAT
LONG DELAY TRANSFER FILE

| ITEM | UNITS/FORMAT | VALUE/RANGE | PRECISION |
|---|---|---|---|
| Archive Flag | /Integer | 0-255 | 1 |
| UTC/GPS Time Difference | | | |
| Time of most recent measurement | GPS Time weeks | $0-2^{10}$ | 1 |
| | secs | 0-604,800 | 1.5 |
| Bias Estimate | Seconds | N/A | DP |
| Drift Estimate | sec/sec | | |
| Reference Time | GPS Time weeks | $0-2^{10}$ | 1 |
| Variance of Bias | $sec^2$ | N/A | DP |
| | secs | 0-604,800 | 1.5 |
| Variance of Drift | $(sec/sec)^2$ | N/A | DP |
| Reference Clock Parameter | | | |
| -Designation | | | |
| GS Reference Number (MS ID) | Integer | 0-255 | I |
| Time of Designation | GPS Time weeks | $0-2^{10}$ | 1 |
| | secs | 0-604,800 | 1.5 |
| -State | | | |
| Bias | Seconds | N/A | DP |
| Drift | sec/sec | N/A | DP |
| Time of last update | GPS Time weeks | $0-2^{10}$ | 1 |
| | secs | 0-604,800 | 1.5 |
| -Deviation from MS Clocks | | | |
| Time of Kalman Update | GPS Time weeks | $0-2^{10}$ | 1 |
| | secs | 0-604,800 | 1.5 |
| GS Reference Number (MS ID) | Integer | 0-255 | 1 |
| Reference-MS Clock | Seconds | N/A | DP |

| | | | |
|---|---|---|---|
| -Deviation from Mean Time<br>Time of Kalman Update | GPS Time weeks<br>secs | $0\text{-}2^{10}$<br>0-604,800 | 1<br>1.5 |
| MS Clock Weights | Dimensionless | 0-1 | 0.05 |
| Mean Time Scale | Seconds | N/A | DP |
| Reference Clock-<br>Mean Time | Seconds | N/A | DP |
| Deviation | Seconds | N/A | DP |
| Drift | Femtoseconds/<br>Seconds | N/A | DP |
| SV Ensemble Allan<br>Variance of Kalman<br>Estimates | | | |
| Allan Variances of<br>Kalman Estimates | $sec^2$ | N/A | DP |
| Delays | Seconds | N/A | DP |
| Navigation Data Message<br>Parameters | | | |
| $A_0$ | $2^{-30}$ seconds | $-2^{31}$ to $2^{31}-1$ | 32 bits |
| $A_1$ | $2^{-70}$ seconds | $-2^{33}$ to $2^{23}-1$ | 24 bits |
| Reference time-of-day | 4096 seconds | 0 to 602112 | 8 bits |
| Reference time week<br>number | weeks | 0-255 | 8 bits |
| Current Leap Second<br>Count | | | |
| Count | Integer | $-2^7$ to $2^7$ | 1 |
| Effective Date-Time | GPS Time weeks<br>secs | $0\text{-}2^{10}$<br>0-604,800 | 1<br>1.5 |

| | | | |
|---|---|---|---|
| Leap Second Advisory Data | | | |
| -Delta time due to leap seconds | Integer | 0-1000 | 10 bits |
| -Number of week effective | Integer | 0-256 | 8 bits |
| -Number of day effective | Integer | 1-7 | 3 bits |
| Clock Offset Models | | | |
| -For each SV: | | | |
| SV Reference Number | Integer | 1-255 | 1 |
| Reference Time | GPS Time weeks | $0-2^{10}$ | 1 |
| | secs | 0-604,800 | 1.5 |
| Polynominal coefficients | | | |
| $A_0$ | Seconds | N/A | DP |
| $A_1$ | Sec/sec | N/A | DP |
| $A_2$ | Sec/sec$^2$ | N/A | DP |
| -For each MS: | | | |
| GA Reference Number (MS ID) | Integer | 0-255 | 1 |
| Reference time | GPS Time weeks | $0-2^{10}$ | 1 |
| | secs | 0-604,800 | 1.5 |
| Polynomial Coefficients | | | |
| $A_0$ | Seconds | N/A | DP |
| $A_1$ | Sec/sec | N/A | DP |

# 40.0 APPENDIX D

Excerpt from ICD-GPS-200
(Section 20, Appendix II,
GPS Navigation Data Structure for Data ID No. 2)

## 20. APPENDIX II. GPS NAVIGATION DATA STRUCTURE FOR DATA ID NO. 2

20.1 Scope. This appendix describes the specific GPS navigation (NAV) data structure denoted by data ID number 2. This data ID number, when transmitted as part of the NAV data, shall be represented by the two-bit binary notation of 01. Data ID number 1 is no longer in use.

20.2 Applicable Documents

20.2.1 Government Documents. In addition to the documents listed in paragraph 2.1, the following documents of the issue specified contribute to the definition of the NAV data related interfaces and form a part of this Appendix to the extent specified herein.

Specifications

None

Standards

None

Other Publications

None

20.2.2 Non-Government Documents. In addition to the documents listed in paragraph 2.2, the following documents of the issue specified contribute to the definition of the NAV data related interfaces and form a part of this Appendix to the extent specified herein.

Specifications

None

Other Publications

None

## 20.3 Requirements

20.3.1 Data Characteristics. The data stream shall be transmitted by the SV on the $L_1$ and $L_2$ channels at a rate of 50 bps. The data stream, when present, shall be common to both of those L-band frequencies, irrespective of the PRN ranging code(s) used.

20.3.2 Message Structure. As shown in Figure 20-1, the message structure shall utilize a basic format of a 1500 bit long frame made up of five subframes, each subframe being 300 bits long. Subframes 4 and 5 shall be subcommutated 25 times each, so that a complete data message shall require the transmission of 25 full frames. The 25 versions of subframes 4 and 5 shall be referred to herein as pages 1 through 25 of each subframe. Each subframe shall consist of ten words, each 30 bits long; the MSB of all words shall be transmitted first.

Each subframe and/or page of a subframe shall contain a telemetry (TLM) word and a handover word (HOW), both generated by the SV, and shall start with the TLM/HOW pair. The TLM word shall be transmitted first, immediately followed by the HOW. The latter shall be followed by eight data words, each of which shall be generated by the CS. Each word in each frame shall contain parity (reference Section 20.3.5). The SV generates (calculates) parity for the TLM and HOW words only; the CS generates parity for all other words of each frame.

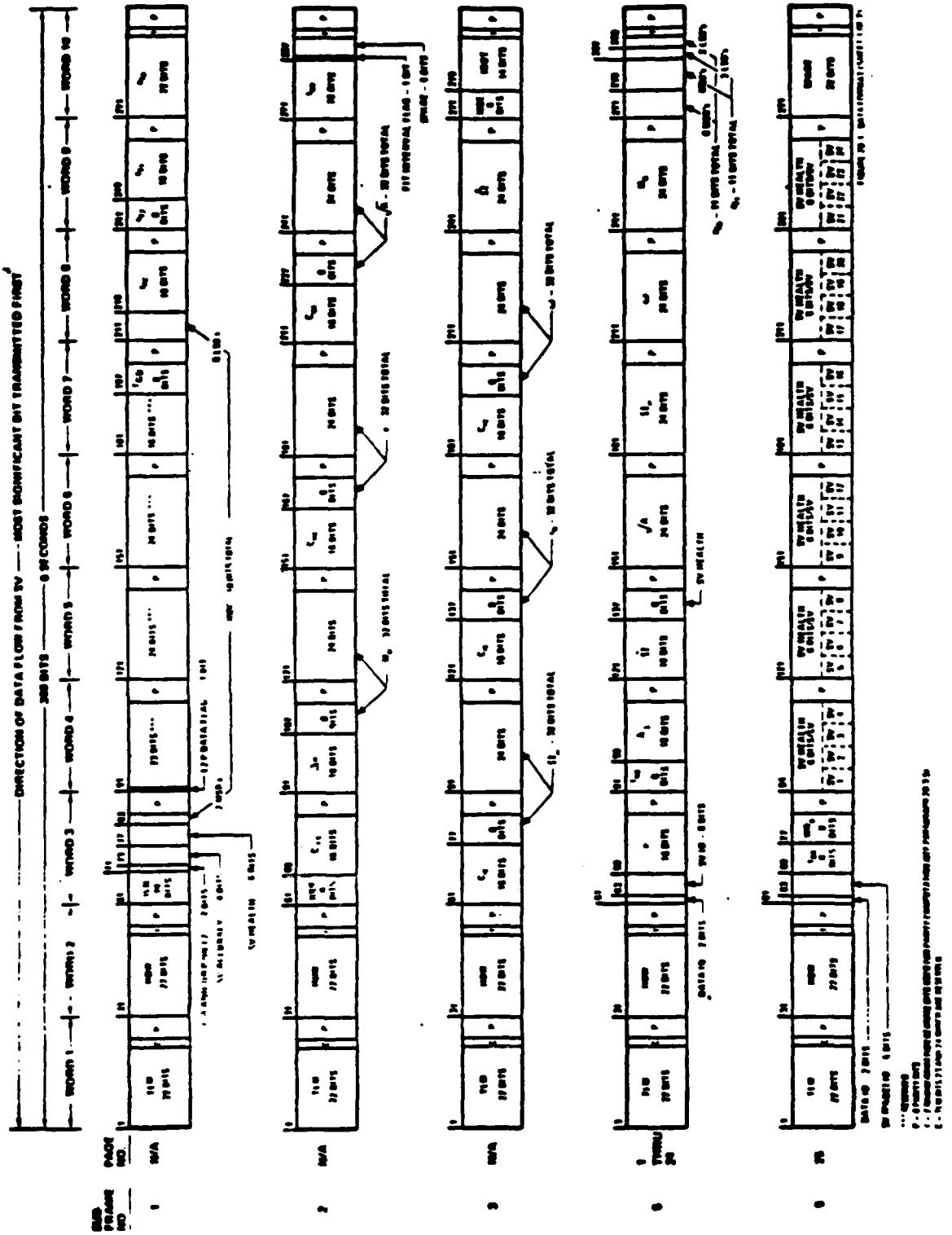

Figure 20-1. Data Format (Sheet 1 of 2)

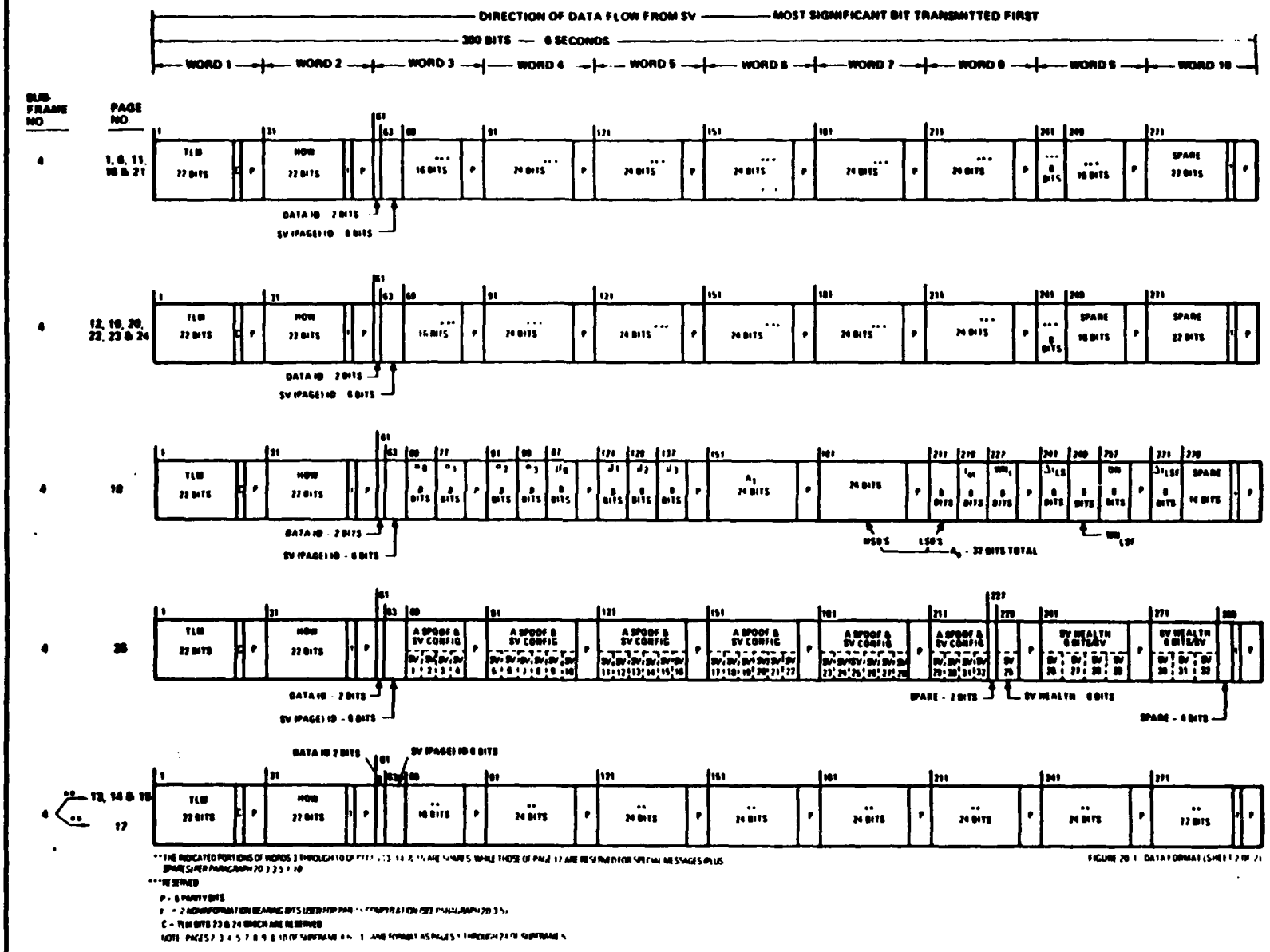


Figure 20-1. Data Format (Sheet 2 of 2)

Block II SV's (SV configuration 001--reference paragraph 20.3.3.5.1.6) are designed with a sufficient memory capacity for storing 14 days of uploaded NAV data. Alternating ones and zeros will be transmitted in words 3 through 10 in place of the normal NAV data whenever the SV cannot locate the requisite valid control or data element in its on-board computer memory. The following specifics apply to this default action: (a) the parity of the affected words will be invalid, (b) the two trailing bits of word 10 will be zeros (to allow the parity of subsequent subframes to be valid--reference paragraph 20.3.5), (c) if the problem is the lack of a data element, only the directly related subframe(s) will be treated in this manner, (d) if a control element cannot be located, this default action will be applied to all subframes and all subframes will indicate ID=1 (i.e. an ID-code of 001) in the HOW (reference paragraph 20.3.3.2) and (e) certain failures of data which may occur in the SV memory or during an upload will cause the SV to transmit in Non-standard codes (NSC and NSY) which would preclude normal use by the US. A table of default conditions is contained in ICD-GPS-201. Normal NAV data transmission will be resumed by the SV whenever a valid set of elements becomes available.

Block I SVs (SV configuration 000--reference paragraph 20.3.3.5.1.6) cannot store 14 days of uploaded data. Whenever Block I SVs reach the end of the uploaded data, they will transmit a pattern of ones and zeros in words 3 through 10 of each subframe with two trailing zeros in word 10. Further, the Block I SVs do not have the capability of transmitting alternating ones and zeros in words 3 through 10 in place of the normal NAV data in default cases specified in the preceding paragraph.

Although the data content of both Block I and Block II SVs will be temporarily reduced during the upload process, the transmission of valid NAV data will be continuous. The data capacity of specific operational SVs may be reduced to accommodate partial memory failures.

20.3.3 Message Content. The format and contents of the TLM word and the HOW, as well as those of words three through ten of each subframe/page, are described in the following subparagraphs (message content related to SA is defined in ICD-GPS-203 and/or ICD-GPS-207 -- see note in paragraph 2.1.). During the first approximately one day period following the uploading of data to a SV, the data sets transmitted by that SV in subframes 1, 2 and 3 will have a transmission period of one hour (i.e. the data content may be different during each 1 hour period to reflect more up-to-date clock and ephemeris information). The corresponding transmission periods during the second through fourteenth days following the upload will be 4 hours. Paragraph 20.3.3.3.3.1 and Section 20.3.3.4.3 provide specifics regarding validity periods for these data sets after their transmission periods, while paragraphs 20.3.4.1 and 20.3.4.4 cover the detail constraints and protocol regarding cutovers from data set to data set.

20.3.3.1 Telemetry Word. Each TLM word is 30 bits long, occurs every six seconds in the data frame, and is the first word in each subframe/page. The format shall be as shown in Figure 20-2. Bit 1 is transmitted first. Each TLM word shall begin with a preamble, followed by the TLM message, two reserved bits, and six parity bits. The TLM message contains information needed by the authorized user as defined in ICD-GPS-203 and/or ICD-GPS-207 (see note in paragraph 2.1), and by the CS, as described in the related SS/CS interfaces documentation.

20.3.3.2 Handover Word (HOW). The HOW shall be 30 bits long and shall be the second word in each subframe/page, immediately following the TLM word. A HOW occurs every six seconds in the data frame. The format and content of the HOW shall be as shown in Figure 20-2. The MSB is transmitted first. The HOW begins with the 17 MSBs of the time-of-week (TOW) count. (The full TOW count consists of the 19 LSBs of the 29-bit Z-count). These 17 bits correspond to the TOW-count at the X1 epoch which occurs at the start (leading edge) of the next following subframe (reference paragraph 3.3.4).

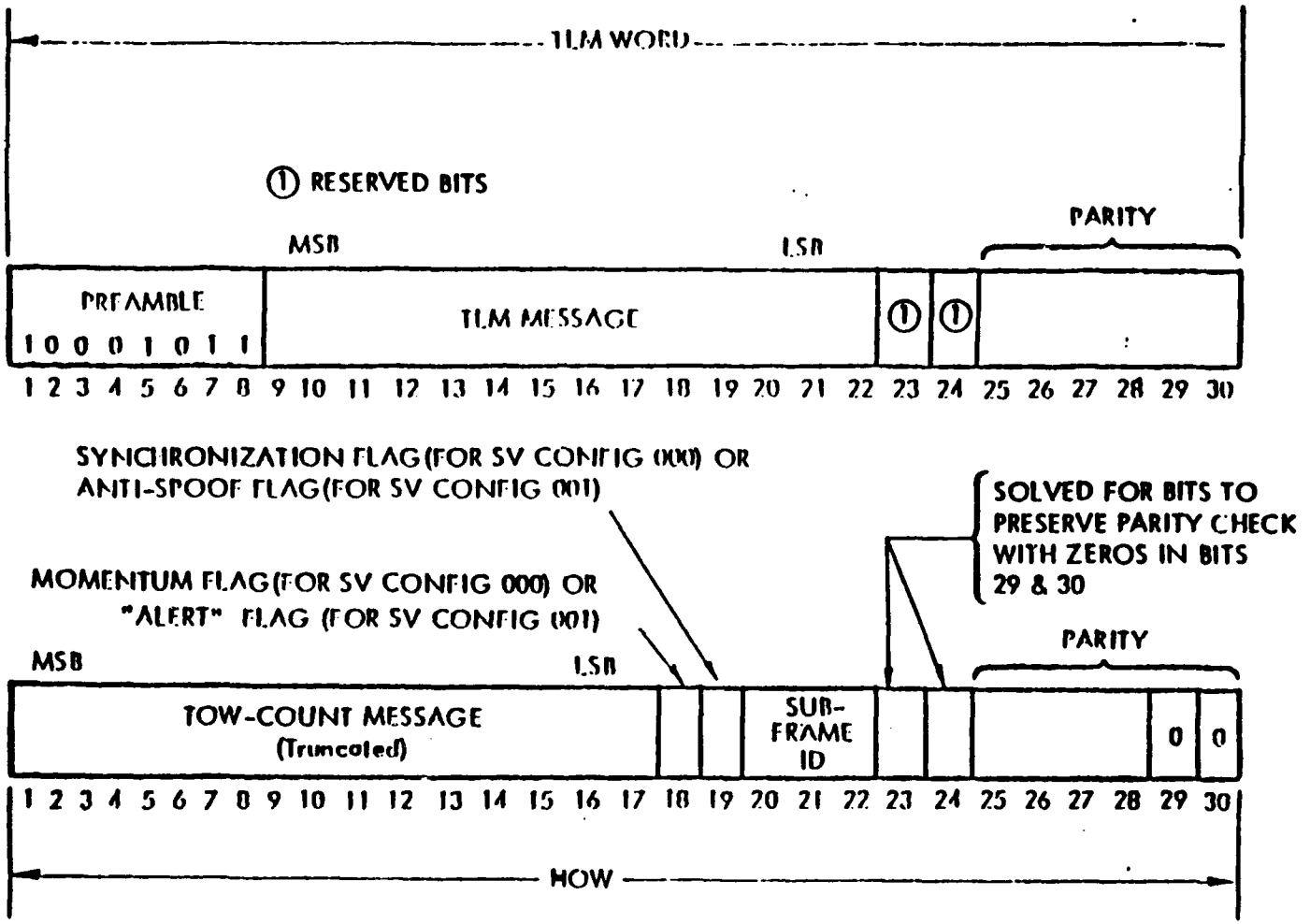


Figure 20-2. TLM and HOW Formats

Bit 18 is used in two ways: (a) on SVs that are designated by configuration code 000, bit 18 is the roll momentum dump flag with a "1" in this bit-position indicating that a non-conservative (thruster type) momentum dump has occurred since the last upload (this flag is reset at a new end-of-message transmission at the conclusion of the next upload); and (b) on SVs designated by configuration code 001, bit 18 is an "alert" flag. When this flag is raised (bit 18 = "1"), it shall indicate to the unauthorized user that the SV URA may be worse than indicated in subframe 1 and that he shall use that SV at his own risk. The authorized user shall refer to ICD-GPS-203 and/or ICSD-GPS-207 (see note in paragraph 2.1).

Bit 19 also has a dual role: (a) on SVs that are designated by configuration code 000 in page 25 of subframe 4, bit 19 is used as a synchronization flag; and (b) on SVs designated by configuration code 001, bit 19 is an anti-spoof (A-S) flag.

When used as a synchronization flag, a "0" in bit position 19 indicates that the SV is in synchronism, which is defined as the condition in which the leading edge of the TLM word is coincident with the X1 epoch. If bit 19 is a "1", this condition may not exist; i.e., the SV is not in synchronism, and further data from this SV should not be used since it may be erroneous. When used as an A-S flag, a "1" in bit-position 19 indicates that the A-S mode is ON in that SV.

Bits 20, 21, and 22 of the HOW provide the ID of the subframe in which that particular HOW is the second word; the ID code shall be as follows:

| Subframe | ID Code |
|---|---|
| 1 | 001 |
| 2 | 010 |
| 3 | 011 |
| 4 | 100 |
| 5 | 101 |

20.3.3.3 Subframe 1. The content of words three through ten of subframe 1 are defined below, followed by related algorithms and material pertinent to use of the data.

20.3.3.3.1 Subframe 1 Content. The third through tenth words of subframe 1 shall each contain six parity bits as their LSBs; in addition, two noninformation bearing bits shall be provided as bits 23 and 24 of word ten for parity computation purposes. The remaining 190 bits of words three through ten shall contain the clock parameters and other data described in the following.

The clock parameters describe the SV time scale during the period of validity. The parameters in a data set shall be valid during the interval of time in which they are transmitted and shall remain valid for an additional period of time after transmission of the next data set has started. For the first approximately one day period following an upload, the period of transmission shall be one hour, while the additional period of data validity shall be three hours; the corresponding time periods for days 2 through 14 shall be four hours and two hours respectively (reference paragraph 20.3.4.4 for specific details on data set transmission periods).

20.3.3.3.1.1 Week Number. The ten MSBs of word three shall contain the ten MSBs of the 29-bit Z-count. These ten bits shall represent the number of the current GPS week of transmission with "all zeros" indicating week "0". The GPS week number increments at each end/start of week epoch.

20.3.3.3.1.2 Code(s) on $L_2$ Channel. Bits 11 and 12 of word three shall indicate which code(s) is (are) commanded ON for the $L_2$ channel, as follows:

00 = Reserved,
01 = P code ON,
10 = C/A code ON.

20.3.3.3.1.3 SV Accuracy. Bits 13 through 16 of word three shall give the predicted user range accuracy (URA) of the SV (reference paragraph 6.2.1) available to the two-frequency (L1 and L2) unauthorized user. (Note: the URA does not include the effect of the single-frequency ionospheric delay model). Referring to the decimal equivalent of the transmitted four-bit binary number as N -- with N a positive integer in the range of 0 through 15 -- the accuracy value shall be defined to mean "no better than X meters", in accordance with the following relationships:

- o If the value of N is 6 or less, $X = 2^{(1 + N/2)}$,
- o If the value of N is 6 or more, but less than 15, $X = 2^{(N-2)}$,
- o N = 15 shall indicate the absence of an accuracy prediction and shall advise the unauthorized user to use that SV at his own risk.

For N = 1, 3, and 5 X shall be rounded to 2.8, 5.7 and 11.3 meters respectively; the above relationships yield integer values of X for all other values of N. Using these values of X the user may utilize a look-up table approach for interpreting the URA message.

20.3.3.3.1.4 SV Health. The six-bit health indication given by bits 17 through 22 of word three refers to the transmitting SV. The MSB shall indicate a summary of the health of the NAV data, where

0 = all NAV data are OK
1 = some or all NAV data are bad.

The five LSBs shall indicate the health of the signal components in accordance with the codes given in paragraph 20.3.3.5.1.3. The health indication shall be given relative to the "as designed" capabilities of each SV (as designated by the configuration code -- see paragraph 20.3.3.5.1.6). Accordingly, any SV which does not have a certain capability will be indicated as "healthy" if the lack of this capability is inherent in its design or it has been configured into a mode which is normal from a user standpoint and does not require that capability.

Additional SV health data are given in subframes 4 and 5. The data given in subframe 1 may differ from that shown in subframes 4 and/or 5 of other SV's since the latter may be updated at a different time.

20.3.3.3.1.5 Issue of Data, Clock (IODC). Bits 23 and 24 of word three in subframe 1 shall be the two MSBs of the ten-bit IODC term; bits one through eight of word eight in subframe 1 shall contain the eight LSBs of the IODC. The IODC indicates the issue number of the data set and thereby provides the user with a convenient means of detecting any change in the correction parameters.

The IODC will be in the range 0 through 1023. Constraints on the IODC as well as the relationship between the IODC and the IODE (issue of data, ephemeris) terms are defined in paragraph 20.3.4.4.

20.3.3.3.1.6 Data Flag for $L_2$ P-Code. When bit 1 of word four is a "1", it shall indicate that the NAV data stream was commanded OFF on the P-code of the $L_2$ channel.

20.3.3.3.1.7 (Reserved).

20.3.3.3.1.8 Estimated Group Delay Differential. Bits 17 through 24 of word seven contain the $L_1$-$L_2$ correction term, $T_{GD}$, for the benefit of "$L_1$ only" or "$L_2$ only" users; the related user algorithm is given in paragraph 20.3.3.3.3.

Figure 20-3. -- (Reserved)

Figure 20-4. -- (Reserved)

20.3.3.3.1.9 SV Clock Correction. Bits nine through 24 of word eight, bits one through 24 of word nine, and bits one through 22 of word ten contain the parameters needed by the users for apparent SV clock correction ($t_{oc}$, $a_{f2}$, $a_{f1}$, $a_{fo}$). The related algorithm is given in paragraph 20.3.3.3.3.

20.3.3.3.2 Subframe 1 Parameter Characteristics. For those parameters whose characteristics are not fully defined in Section 20.3.3.3.1, the number of bits, the scale factor of the LSB (which shall be the last bit received), the range, and the units shall be as specified in Table 20-I.

20.3.3.3.3 User Algorithms for Subframe 1 Data. The algorithms defined below (a) allow all users to correct the code phase time received from the SV with respect to both SV code phase offset and relativistic effects, (b) permit the "single frequency" ($L_1$ or $L_2$) user to compensate for the effects of SV group delay differential (the user who utilizes both frequencies does not require this correction, since the clock parameters account for the induced effects), and (c) allow the "two frequency" ($L_1$ and $L_2$) user to correct for the group propagation delay due to ionospheric effects (the single frequency user may correct for ionospheric effects as described in paragraph 20.3.3.5.2.5).

Table 20-I. Subframe 1 Parameters

| Parameter | No. of Bits** | Scale Factor (LSB) | Effective Range*** | Units |
|---|---|---|---|---|
| Code on $L_2$ | 2 | 1 | | discretes |
| Week No. | 10 | 1 | | Week |
| $L_2$ P data flag | 1 | 1 | | discrete |
| SV accuracy | 4 | | | (see text) |
| SV health | 6 | 1 | | discretes |
| $T_{GD}$ | 8 * | $2^{-31}$ | | seconds |
| IODC | 10 | | | (see text) |
| $t_{oc}$ | 16 | $2^{4}$ | 604,784 | seconds |
| $a_{f2}$ | 8 * | $2^{-55}$ | | $sec/sec^2$ |
| $a_{f1}$ | 16 * | $2^{-43}$ | | sec/sec |
| $a_{fo}$ | 22 * | $2^{-31}$ | | seconds |

* Parameters so indicated shall be two's complement, with the sign bit (+ or -) occupying the MSB;

** See Figure 20-1 for complete bit allocation in subframe;

*** Unless otherwise indicated in this column, effective range is the maximum range attainable with indicated bit allocation and scale factor.

20.3.3.3.3.1 User Algorithm for SV Clock Correction. The polynomial defined in the following allows the user to determine the effective SV PRN code phase offset referenced to the phase center of the SV antennas ($\Delta t_{sv}$) with respect to GPS system time (t) at the time of data transmission. The coefficients transmitted in subframe 1 describe the offset apparent to the two-frequency user for the interval of time in which the parameters are transmitted. This estimated correction accounts for the deterministic SV clock error characteristics of bias, drift and aging, as well as for the SV implementation characteristics of group delay bias and mean differential group delay. Since these coefficients do not include corrections for relativistic effects, the user's equipment must determine the requisite relativistic correction. Accordingly, the offset given below includes a term to perform this function.

The user shall correct the time received from the SV with the equation (in seconds)

$$t = t_{sv} - \Delta t_{sv} \quad (1)$$

where

$t$ = GPS system time (seconds),

$t_{sv}$ = effective SV PRN code phase time at message transmission time (seconds),

$\Delta t_{sv}$ = SV PRN code phase time offset (seconds).

The SV PRN code phase offset is given by

$$\Delta t_{sv} = a_{f0} + a_{f1}(t - t_{oc}) + a_{f2}(t - t_{oc})^2 + \Delta t_r \quad (2)$$

where $a_{f0}$, $a_{f1}$, and $a_{f2}$ are the polynomial coefficients given in subframe 1, $t_{oc}$ is the clock data reference time in seconds (reference paragraph 20.3.4.5), and $\Delta t_r$ is the relativistic correction term (seconds) which is given by

$$\Delta t_r = F\ e\ (A)^{1/2} \sin E_k. \qquad (3)$$

The orbit parameters (e, A, $E_k$) used here are described in discussions of data contained in subframes 2 and 3, while F is a constant whose value is

$$F = \frac{-2(\mu)^{1/2}}{c^2} = -4.442807633\ (10)^{-10}\ \text{sec/(meter)}^{1/2}.$$

where

$\mu = 3.986005 \times 10^{14}$ $\frac{\text{meters}^3}{\text{second}^2}$ = value of earths universal gravitional parameters

$c = 2.99792458 \times 10^{8}$ $\frac{\text{meters}}{\text{second}}$ = speed of light

Note that equations (1) and (2), as written, are coupled. While the coefficients $a_{f0}$, $a_{f1}$, and $a_{f2}$ are generated by using GPS time as indicated in equation (2), sensitivity of $t_{sv}$ to t is negligible. This negligible sensitivity will allow the user to approximate t by $t_{sv}$ in equation (2). The value of t must account for beginning or end of week crossovers. That is, if the quantity $t - t_{oc}$ is greater than 302,400 seconds, subtract 604,800 seconds from t. If the quanity $t - t_{oc}$ is less than -302,400 seconds, add 604,800 seconds to t.

The control segment will utilize the following alternative but equivalent expression for the relativistic correction when estimating the NAV parameters:

$$\Delta t_r = -\frac{2\ \vec{R}\ \vec{V}}{c^2},$$

where

$\vec{R}$ is the instantaneous position vector of the SV,

$\vec{V}$ is the instantaneous velocity vector of the SV, and

c is the speed of light. (Reference paragraph 20.3.4.3).

20.3.3.3.3.2 $L_1 - L_2$ Correction. The $L_1$ and $L_2$ correction term, $T_{GD}$, is calculated by the CS to account for the effect of SV group delay differential between $L_1$ and $L_2$ based on measurements made by the SV contractor during factory testing. This correction term is only for the benefit of "single-frequency" ($L_1$ or $L_2$) users; it is necessitated by the fact that the SV clock offset estimates reflected in the $a_{f0}$ clock correction coefficient (see paragraph 20.3.3.3.3.1) are based on the effective PRN code phase as apparent with two frequency ionospheric corrections. Thus, the user who utilizes the $L_1$ frequency only shall modify the code phase offset in accordance with paragraph 20.3.3.3.3.1 with the equation

$$(\Delta t_{SV})_{L_1} = \Delta t_{SV} - T_{GD}$$

where $T_{GD}$ is provided to the user as subframe 1 data. For the user who utilizes $L_2$ only, the code phase modification is given by

$$(\Delta t_{SV})_{L_2} = \Delta t_{SV} - \gamma T_{GD}$$

where, denoting the nominal center frequencies of $L_1$ and $L_2$ as $f_{L_1}$ and $f_{L_2}$ respectively,

$$\gamma = (f_{L_1}/f_{L_2})^2 = (1575.42/1227.6)^2 = (77/60)^2.$$

The value of $T_{GD}$ is not equal to the mean SV group delay differential, but that delay multiplied by $1/(1 - \gamma)$. That is,

$$T_{GD} = \frac{1}{1 - \gamma}(t_{L_1} - t_{L_2})$$

where $t_{L_1}$ is the GPS time the $i^{th}$ frequency signal is transmitted from the SV.

20.3.3.3.3.3 Ionospheric Correction. The "two frequency" ($L_1$ and $L_2$) user shall correct for the group delay due to ionospheric effects by applying the relationship:

$$PR = \frac{PR_2 - \gamma PR_1}{1 - \gamma}$$

where

PR = pseudorange corrected for ionospheric effects,

$PR_1$ = pseudorange measured on the L-band channel indicated by the subscript,

while $\gamma$ is as defined in paragraph 20.3.3.3.3.2. The clock correction coefficients are based on "two frequency" measurements and therefore account for the effects of mean differential delay in SV instrumentation.

20.3.3.3.3.4 Example Application of Correction Parameters. A typical system application of the correction parameters for a user receiver is shown in Figure 20-5. The ionospheric model referred to in Figure 20-5 is discussed in paragraph 20.3.3.5.2.5 in conjunction with the related data contained in page 18 of subframe 4.

20.3.3.4 Subframes 2 and 3. The contents of words three through ten of subframes 2 and 3 are defined below, followed by material pertinent to the use of the data.

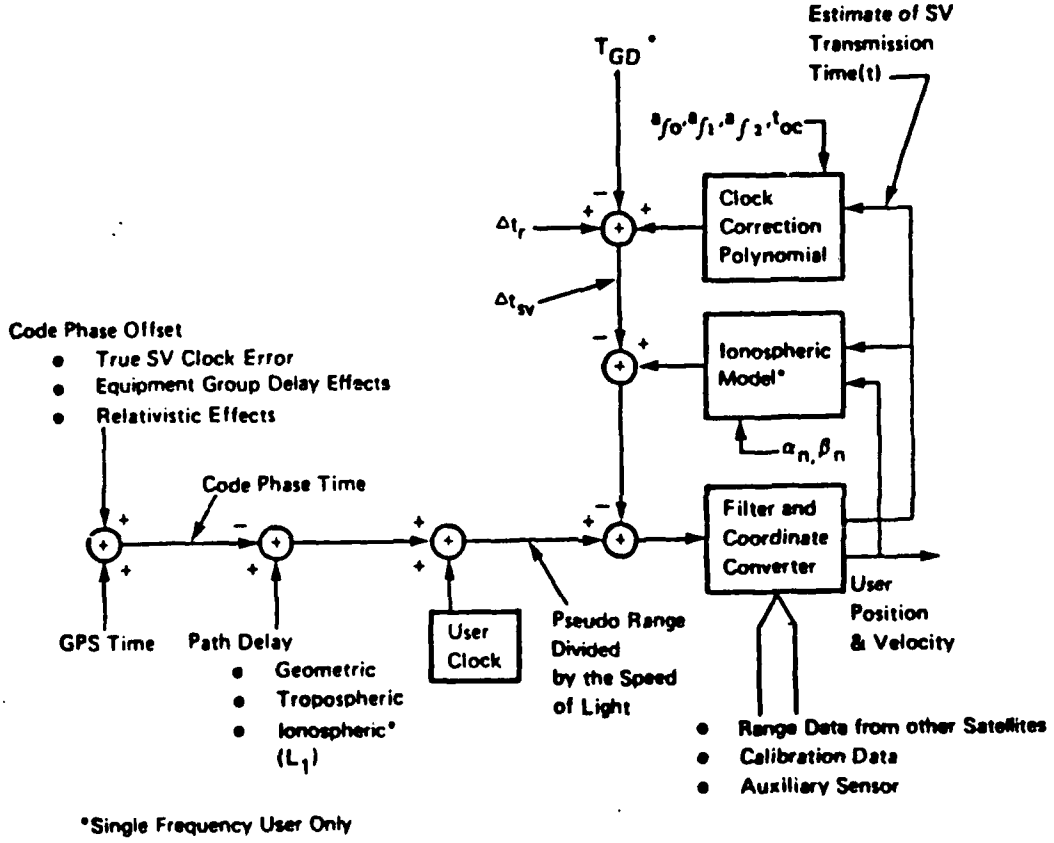


Figure 20-5. Sample Application of Correction Parameters

20.3.3.4.1 Content of Subframes 2 and 3. The third through tenth words of subframes 2 and 3 shall each contain six parity bits as their LSBs; in addition, two noninformation bearing bits shall be provided as bits 23 and 24 of word ten of each subframe for parity computation purposes. Bits 288 through 292 of subframe 2 shall be spares containing alternating ones and zeros with valid parity (Reference Paragraph 20.3.3.5.1.11). The remaining 375 bits of those two subframes shall contain the ephemeris representation parameters of the transmitting SV.

The ephemeris parameters describe the orbit during the interval of time in which the parameters are transmitted. The parameters in a data set shall remain valid for an additional period of time after transmission of the next data set has started. For the first approximately one-day period following an upload, the period of transmission shall be nominally one hour, while the additional period of data validity shall be three hours; the corresponding time periods for days two through 14 shall be a transmission period of four hours with an additional validity period of two hours. (Reference paragraph 20.3.4.4 for specific details on data set transmission periods). Table 20-II gives the definition of the orbital parameters using terminology typical of Keplerian orbital parameters; it shall be noted, however, that the transmitted parameter values are expressed for a coordinate system which allows the best trajectory fit in Earth fixed coordinates for each specific fit interval. The user shall not interpret intermediate coordinate values as pertaining to any conventional or stable coordinate system.

Table 20-II. Ephemeris Data Definitions

| | |
|---|---|
| $M_o$ | MEAN ANOMALY AT REFERENCE TIME |
| $\Delta n$ | MEAN MOTION DIFFERENCE FROM COMPUTED VALUE |
| e | ECCENTRICITY |
| $(A)^{1/2}$ | SQUARE ROOT OF THE SEMI-MAJOR AXIS |
| $(OMEGA)_o$ | LONGITUDE OF ASCENDING NODE OF ORBIT PLANE AT WEEKLY EPOCH. |
| $i_o$ | INCLINATION ANGLE AT REFERENCE TIME |
| $\omega$ | ARGUMENT OF PERIGEE |
| OMEGADOT | RATE OF RIGHT ASCENSION |
| IDOT | RATE OF INCLINATION ANGLE |
| $C_{uc}$ | AMPLITUDE OF THE COSINE HARMONIC CORRECTION TERM TO THE ARGUMENT OF LATITUDE |
| $C_{us}$ | AMPLITUDE OF THE SINE HARMONIC CORRECTION TERM TO THE ARGUMENT OF LATITUDE |
| $C_{rc}$ | AMPLITUDE OF THE COSINE HARMONIC CORRECTION TERM TO THE ORBIT RADIUS |
| $C_{rs}$ | AMPLITUDE OF THE SINE HARMONIC CORRECTION TERM TO THE ORBIT RADIUS |
| $C_{ic}$ | AMPLITUDE OF THE COSINE HARMONIC CORRECTION TERM TO THE ANGLE OF INCLINATION |
| $C_{is}$ | AMPLITUDE OF THE SINE HARMONIC CORRECTION TERM TO THE ANGLE OF INCLINATION |
| $t_{oe}$ | REFERENCE TIME EPHEMERIS (reference paragraph 20.3.4.5) |
| IODE | ISSUE OF DATA (EPHEMERIS) |

The issue of ephemeris data (IODE) term shall provide the user with a convenient means for detecting any change in the ephemeris representation parameters. The CS shall assign issue numbers 0 through 255 to each generated data set so as to be consistent with the 8 LSBs of the IODE term in subframe 1 of the data set (reference paragraphs 20.3.3.3.1.5 and 20.3.4.4).

The IODE word is provided in both subframes for linkage between the two subframes. Whenever the IODE received in subframe 3 is different from that received in subframe 2, the difference indicates that new data are from different data sets and must not be used together (i.e. a data set cutover has occurred and the collection process must be extended until the received IODE words agree). The CS shall ensure that any change in the subframe 2 and 3 data will be accomplished with a simultaneous change in both IODE words. The CS shall also assure that the $t_{oe}$ value, for at least the first data set transmitted by an SV after an upload, is different from that transmitted prior to the cutover.

A "fit interval" flag is provided in subframe 2 to indicate whether the ephemerides are based on a 4-hour or a 6-hour curve fit interval (reference paragraph 20.3.3.4.3).

20.3.3.4.2 Subframe 2 and 3 Parameter Characteristics. For each parameter contained in subframes 2 and 3, the number of bits, the scale factor of the LSB (which shall be the last bit received), the range, and the units shall be as specified in Table 20-III.

Table 20-III. Ephemeris Parameters
(Sheet 1 of 2)

| Parameter | No. of Bits** | Scale Factor (LSB) | Effective Range*** | Units |
|---|---|---|---|---|
| IODE | 8 | | | (see text) |
| $C_{rs}$ | 16 * | $2^{-5}$ | | meters |
| $\Delta n$ | 16 * | $2^{-43}$ | | semi-circles/sec |
| $M_o$ | 32 * | $2^{-31}$ | | semi-circles |
| $C_{uc}$ | 16 * | $2^{-29}$ | | radians |
| e | 32 | $2^{-33}$ | 0.03 | dimensionless |
| $C_{us}$ | 16 * | $2^{-29}$ | | radians |
| $(A)^{1/2}$ | 32 | $2^{-19}$ | | $meters^{1/2}$ |
| $t_{oe}$ | 16 | $2^{4}$ | 604,784 | seconds |

* Parameters so indicated shall be two's complement, with the sign bit (+ or -) occupying the MSB;

** See Figure 20-1 for complete bit allocation in subframe;

*** Unless otherwise indicated in this column, effective range is the maximum range attainable with indicated bit allocation and scale factor.

Table 20-III. Ephemeris Parameters
(Sheet 2 of 2)

| Parameter | No. of Bits** | Scale Factor (LSB) | Effective Range*** | Units |
|---|---|---|---|---|
| $C_{ic}$ | 16 * | $2^{-29}$ | | radians |
| $(OMEGA)_o$ | 32 * | $2^{-31}$ | | semi-circles |
| $C_{is}$ | 16 * | $2^{-29}$ | | radians |
| $i_o$ | 32 * | $2^{-31}$ | | semi-circles |
| $C_{rc}$ | 16 * | $2^{-5}$ | | meters |
| $\omega$ | 32 * | $2^{-31}$ | | semi-circles |
| OMEGADOT | 24 * | $2^{-43}$ | | semi-circles/sec |
| IDOT | 14 * | $2^{-43}$ | | semi-circles/sec |

* Parameters so indicated shall be two's complement, with the sign bit (+ or -) occupying the MSB;

** See Figure 20-1 for complete bit allocation in subframe;

*** Unless otherwise indicated in this column, effective range is the maximum range attainable with indicated bit allocation and scale factor.

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20.3.3.4.3 User Algorithm for Ephemeris Determination. The user shall compute the earth fixed coordinates of position for the phase center of the SV's antennas utilizing a variation of the equations shown in Table 20-IV. Subframes 2 and 3 parameters are Keplerian in appearance; the values of these parameters, however, are obtained via a least squares curve fit of the predicted ephemeris for the phase center of the SV's antennas (time-position quadruples; t, x, y, z). Particulars concerning the periods of the curve fit, the resultant accuracy, and the applicable coordinate system are given in the following subparagraphs.

20.3.3.4.3.1 Curve Fit Intervals. The data sets transmitted during the first approximately one-day period after an upload shall be based on curve fits over four-hour intervals. For data sets transmitted during the second through fourteenth day after an upload, the curve fits shall be over six-hour intervals (refer to paragraph 20.3.4.4 for specific details on the length of data set transmission periods). Bit 17 in word 10 of subframe 2 is a "fit interval" flag which indicates the curve-fit interval used by the CS in determining the ephemeris parameters, as follows:

0 = 4 hours,
1 = 6 hours.

20.3.3.4.3.2 User Range Error. The figure of merit used to measure the quality of this curve fit is User Range Error (URE) based on a projection of the curve fit error onto the user range. For data sets with a four-hour fit interval (transmitted during the first approximately one-day period after upload), the curve fit procedure used provides URE component to the predicted SV ephemeris of less than 0.35 meter, one sigma. Truncation of the parameters increases the one sigma error to 0.4 meter. These URE values apply while the data set is transmitted as well as for a period of 3 hours thereafter.

## Table 20-IV. Elements of Coordinate Systems

| | |
|---|---|
| $\mu = 3.986005 \times 10^{14} \frac{meters^3}{sec^2}$ | WGS 84 VALUE OF THE EARTH'S UNIVERSAL GRAVITATIONAL PARAMETER |
| $\dot{\Omega}_e = 7.2921151467 \times 10^{-5} \frac{rad}{sec}$ | WGS 84 VALUE OF THE EARTH'S ROTATION RATE |
| $A = (\sqrt{A})^2$ | SEMI-MAJOR AXIS |
| $n_o = \sqrt{\frac{\mu}{A^3}}$ | COMPUTED MEAN MOTION—radians/second |
| $t_k = t - t_{oe}$* | TIME FROM EPHEMERIS REFERENCE EPOCH |
| $n = n_o + \Delta n$ | CORRECTED MEAN MOTION |
| $M_k = M_o + nt_k$ | MEAN ANOMALY |
| $M_k = E_k - e \sin E_k$ | KEPLER'S EQUATION FOR ECCENTRIC ANOMALY (MAY BE SOLVED BY ITERATION)—radians |
| $v_k = \tan^{-1}\left\{\frac{\sin v_k}{\cos v_k}\right\} = \tan^{-1}\left\{\frac{\sqrt{1-e^2}\sin E_k/(1-e\cos E_k)}{(\cos E_k - e)/(1-e\cos E_k)}\right\}$ | TRUE ANOMALY |
| $E_k = \cos^{-1}\left\{\frac{e + \cos v_k}{1 + e\cos v_k}\right\}$ | ECCENTRIC ANOMALY |
| $\Phi_k = v_k + \omega$ | ARGUMENT OF LATITUDE |
| $\delta u_k = C_{us}\sin 2\Phi_k + C_{uc}\cos 2\Phi_k$ | Argument of Latitude Correction — SECOND HARMONIC PERTURBATIONS |
| $\delta r_k = C_{rc}\cos 2\Phi_k + C_{rs}\sin 2\Phi_k$ | Radius Correction — SECOND HARMONIC PERTURBATIONS |
| $\delta i_k = C_{ic}\cos 2\Phi_k + C_{is}\sin 2\Phi_k$ | Correction to Inclination — SECOND HARMONIC PERTURBATIONS |
| $u_k = \Phi_k + \delta u_k$ | CORRECTED ARGUMENT OF LATITUDE |
| $r_k = A(1 - e\cos E_k) + \delta r_k$ | CORRECTED RADIUS |
| $i_k = i_o + \delta i_k + (IDOT)\,t_k$ | CORRECTED INCLINATION |
| $x_k' = r_k \cos u_k$<br>$y_k' = r_k \sin u_k$ | POSITIONS IN ORBITAL PLANE |
| $\Omega_k = \Omega_o + (\dot{\Omega} - \dot{\Omega}_e)\,t_k - \dot{\Omega}_e t_{oe}$ | CORRECTED LONGITUDE OF ASCENDING NODE |
| $x_k = x_k' \cos\Omega_k - y_k' \cos i_k \sin\Omega_k$<br>$y_k = x_k' \sin\Omega_k + y_k' \cos i_k \cos\Omega_k$<br>$z_k = y_k' \sin i_k$ | EARTH FIXED COORDINATES |

*t is GPS system time at time of transmission, i.e., GPS time corrected for transit time (range/speed of light). Furthermore, $t_k$ shall be the actual total time difference between the time t and the epoch time $t_{oe}$, and must account for beginning or end of week crossovers. That is, if $t_k$ is greater than 302,400 seconds, subtract 604,800 seconds from $t_k$. If $t_k$ is less than -302,400 seconds, add 604,800 seconds to $t_k$.

For data sets with a six-hour fit interval (transmitted during the second through fourteenth days after an upload), the curve fit procedure used provides URE component to the predicted SV ephemeris of less than 1.5 meter, one sigma. Truncation of the parameters increases the one sigma error to 1.6 meter. These URE values apply while the data set is being transmitted, as well as for a period of 2 hours thereafter.

20.3.3.4.3.3 Parameter Sensitivity. The sensitivity of the SV's antenna phase center position to small perturbations in most ephemeris parameters is extreme. The sensitivity of position to the parameters $(A)^{1/2}$, $C_{rc}$ and $C_{rs}$ is about one meter/meter. The sensitivity of position to the angular parameters is on the order of $10^{8}$ meters/semi-circle, and to the angular rate parameters is on the order of $10^{12}$ meters/semi-circle/second. Because of this extreme sensitivity to angular perturbations, the value of $\pi$ used in the curve fit is given here. $\pi$ is a mathematical constant, the ratio of a circle's circumference to its diameter. Here $\pi$ is taken as

$$\pi = 3.1415926535898.$$

20.3.3.4.3.4 Coordinate System. The equations given in Table 20-IV provide the SV's antenna phase center position in the WGS 84 earth-centered earth-fixed reference frame defined as follows:

ORIGIN = Earth's center of mass*

Z-AXIS = Parallel to the direction of the CONVENTIONAL INTERNATIONAL ORIGIN (CIO) for polar motion, as defined by the BUREAU INTERNATIONAL DE L'HEURE (BIH) on the basis of the latitudes adopted for the BIH stations**

X-AXIS = Intersection of the WGS 84 reference meridian plane and the plane of the mean astronomic equator, the reference meridian being parallel to the zero meridian defined by the BUREAU INTERNATIONAL DE L'HEURE (BIH) on the basis of the longitudes adopted for the BIH stations***

Y-AXIS = Completes a right-handed earth-centered, earth-fixed orthogonal coordinate system, measured in the plane of the mean astronomic equator 90° east of the X-axis***

* Geometric center of WGS 84 ellipsoid

** Rotation axis of WGS 84 ellipsoid

*** X, Y axes of WGS 84 ellipsoid

20.3.3.4.3.5 Geometric Range. The user shall account for the effects due to earth rotation rate (reference Table 20-IV) during the time of signal propagation so as to evaluate the path delay in an inertially stable coordinate system.

20.3.3.5 Subframes 4 and 5. Both subframe 4 and 5 are subcommutated 25 times each; the 25 versions of these subframes are referred to as pages 1 through 25 of each subframe. With the possible exception of "spare" pages and explicit repeats, each page contains different specific data in words three through ten. As shown in Figure 20-1, the pages of subframe 4 utilize six different formats, while those of subframe 5 use two. The content of words three through ten of each page is described below, followed by algorithms and material pertinent to the use of the data.

20.3.3.5.1 Content of Subframes 4 and 5. Words three through ten of each page contain six parity bits as their LSBs; in addition, two noninformation bearing bits are provided as bits 23 and 24 of word ten in each page for parity computation purposes. The data contained in the remaining bits of words three through ten of the various pages in subframes 4 and 5 are described in the following subparagraphs.

A brief summary of the various data contained in each page of subframes 4 and 5 is as follows:

a. Subframe 4:

- o Pages 1, 6, 11, 16, and 21: (reserved);
- o Pages 2, 3, 4, 5, 7, 8, 9, and 10: almanac data for SV 25 through 32 respectively; These pages may be designated for other functions; the format and content for each page is defined by the SV ID of that page. In this case, the six-bit health word of page 25 is set to "6 ones" (Refer to 20.3.3.5.1.3) and the SV ID of the page will not have a value in the range of 25 through 32;
- o Pages 12, 19, 20, 22, 23, and 24: (reserved);
- o Pages 13, 14, and 15: spares;
- o Page 17: special messages;
- o Page 18: ionospheric and UTC data;
- o Page 25: A-S flags/SV configurations for 32 SVs, plus SV health for SV 25 through 32.

b. Subframe 5:

- o Pages 1 through 24: almanac data for SV 1 through 24;
- o Page 25: SV health data for SV 1 through 24, the almanac reference time and the almanac reference week number.

20.3.3.5.1.1 Data ID and SV ID. The two MSBs of word three in each page shall contain the data ID which defines the applicable GPS NAV data structure. Data ID one (denoted by binary code 00) was utilized during Phase I of the GPS program and is no longer in use; data ID two (denoted by binary code 01) is described in this Appendix. Future data IDs will be defined as necessary.

As shown in Table 20-V, the data ID is utilized to provide one of two indications: (a) for those pages which are assigned to contain the almanac data of one specific SV, the data ID defines the data structure utilized by that SV whose almanac data are contained in that page; and (b) for all other pages, the data ID denotes the data structure of the transmitting SV.

The SV ID is given by bits three through eight of word three in each page as shown in Table 20-V. Specific IDs are reserved for each page of subframe 4 and 5; however, the SV ID of pages 2, 3, 4, 5, 7, 8, 9 and 10 of subframe 4 may change for each page to reflect the alternate contents for that page. The SV IDs are utilized in two different ways: (a) for those pages which contain the almanac data of a given SV, the SV ID is the same number that is assigned to the PRN code phase of that SV (reference Table 3-I), and (b) for all other pages the SV ID assigned in accordance with Table 20-V serves as the "page ID". IDs 1 through 32 are assigned to those pages which contain the almanac data of specific SVs (pages 1-24 of subframe 5 and pages 2-5 plus 7-10 of subframe 4). The "0" ID (binary all zeros) is assigned to indicate a dummy SV, while IDs 51 through 63 are utilized for pages containing other than almanac data of a specific SV. The remaining IDs (33 through 50) are unassigned.

Pages which contain identical data (for more frequent repetition) carry the same SV ID (e.g., in subframe 4, pages 1, 6, 11, 16, and 21 carry an ID of 57, while pages 12 and 24 are designated by an ID of 62).

Table 20-V. Data IDs and SV IDs in Subframes 4 and 5

| | Subframe 4 | | Subframe 5 | |
|---|---|---|---|---|
| Page | Data ID | SV ID* | DATA ID | SV ID* |
| 1 | Note (2) | 57 | Note (1) | 1 |
| 2 | Note (1) | 25 | Note (1) | 2 |
| 3 | Note (1) | 26 | Note (1) | 3 |
| 4 | Note (1) | 27 | Note (1) | 4 |
| 5 | Note (1) | 28 | Note (1) | 5 |
| 6 | Note (2) | 57 | Note (1) | 6 |
| 7 | Note (1) | 29 | Note (1) | 7 |
| 8 | Note (1) | 30 | Note (1) | 8 |
| 9 | Note (1) | 31 | Note (1) | 9 |
| 10 | Note (1) | 32 | Note (1) | 10 |
| 11 | Note (2) | 57 | Note (1) | 11 |
| 12 | Note (2) | 62 | Note (1) | 12 |
| 13 | Note (2) | 52 | Note (1) | 13 |
| 14 | Note (2) | 53 | Note (1) | 14 |
| 15 | Note (2) | 54 | Note (1) | 15 |
| 16 | Note (2) | 57 | Note (1) | 16 |
| 17 | Note (2) | 55 | Note (1) | 17 |
| 18 | Note (2) | 56 | Note (1) | 18 |
| 19 | Note (2) | 58 | Note (1) | 19 |
| 20 | Note (2) | 59 | Note (1) | 20 |
| 21 | Note (2) | 57 | Note (1) | 21 |
| 22 | Note (2) | 60 | Note (1) | 22 |
| 23 | Note (2) | 61 | Note (1) | 23 |
| 24 | Note (2) | 62 | Note (1) | 24 |
| 25 | Note (2) | 63 | Note (2) | 51 |

Notes:
* Use "0" to indicate "dummy" SV. When using "0" to indicate dummy SV, use the data ID of the transmitting SV.
(1) Data ID of that SV whose SV ID appears in that page.
(2) Data ID of transmitting SV.
(3) Pages 2, 3, 4, 5, 7, 8, 9 and 10 of subframe 4 may contain almanac data for SV 25 through 32, respectively, or data for other functions as identified by a different SV ID from the value shown.

20.3.3.5.1.2 Almanac Data. Pages 1 through 24 of subframe 5, as well as pages 2 through 5 and 7 through 10 of subframe 4 contain the almanac data and a SV health word for up to 32 SVs (the health word is discussed in paragraph 20.3.3.5.1.3). The almanac data are a reduced-precision subset of the clock and ephemeris parameters. The data occupy all bits of words three through ten of each page except the eight MSBs of word three (data ID and SV ID), bits 17 through 24 of word five (SV health), and the 50 bits devoted to parity. The number of bits, the scale factor (LSB), the range, and the units of the almanac parameters are given in Table 20-VI. The algorithms and other material related to the use of the almanac data are given in paragraph 20.3.3.5.2. The almanac parameters shall be updated by the CS at least once every 6 days.

The almanac message for any dummy SVs shall contain alternating ones and zeros with valid parity. For twelve or fewer SVs, almanacs may be repeated within the 25-cycle subcommutation limit. Whenever this option is exercised, the following constraints shall apply: (a) each page of subframes 4 and 5, which is assigned by Table 20-V to one of the active SVs in orbit, must contain the almanac data of that SV to which it is assigned by Table 20-V, (b) those almanac-type pages which remain unused per the above rule, shall then be reassigned to carry a duplicate set of almanac data for the active orbiting SVs, (c) these page reassignments shall be in ascending order of page numbers (starting with subframe 5, followed by subframe 4) being used for SVs having an ascending order of SV IDs, and (d) each reassigned page must carry the SV ID of that SV whose almanac data it contains.

Table 20-VI. Almanac Parameters

| Parameter | No. of Bits** | Scale Factor (LSB) | Effective Range*** | Units |
|---|---|---|---|---|
| e | 16 | $2^{-21}$ | | dimensionless |
| $t_{oa}$ | 8 | $2^{12}$ | 602,112 | seconds |
| $\delta_i$**** | 16 * | $2^{-19}$ | | semi circles |
| OMEGADOT | 16 * | $2^{-38}$ | | semi circles/sec |
| $(A)^{1/2}$ | 24 | $2^{-11}$ | | meters $^{1/2}$ |
| $(OMEGA)_o$ | 24 * | $2^{-23}$ | | semi circles |
| $\omega$ | 24 * | $2^{-23}$ | | semi circles |
| $M_o$ | 24 * | $2^{-23}$ | | semi circles |
| $a_{fo}$ | 11 * | $2^{-20}$ | | seconds |
| $a_{f1}$ | 11 * | $2^{-38}$ | | sec/sec |

* Parameters so indicated shall be two's complement, with the sign bit (+ or -) occupying the MSB;

** See Figure 20-1 for complete bit allocation in subframe;

*** Unless otherwise indicated in this column, effective range is the maximum range attainable with indicated bit allocation and scale factor;

**** Relative to $i_o$ = 0.30 semi-circles.

20.3.3.5.1.3 SV Health. Subframes 4 and 5 contain two types of SV health data: (a) each of the 32 pages which contain the clock/ephemeris related almanac data provide an eight-bit SV health status word regarding the SV whose almanac data they carry, and (b) the 25$^{th}$ pages of subframe 4 and of subframe 5 jointly contain six-bit health status data for up to 32 SVs. This health data will be updated at time of clock and ephemeris parameter upload whenever a change of health status in the constellation is known at the time of almanac data preparation.

The three MSBs of the eight-bit health words indicate health of the NAV data in accordance with the code given in Table 20-VII. The six-bit words provide a one-bit summary of the NAV data's health status in the MSB position in accordance with paragraph 20.3.3.3.1.4. The five LSBs of both the eight-bit and the six-bit health words provide the health status of the SV's signal components in accordance with the code given in Table 20-VIII. A special meaning is assigned, however, to the "6 ones" combination of the six-bit health words in the 25$^{th}$ pages of subframes 4 and 5: it indicates that "the SV which has that ID is not available and there maybe no data regarding that SV in that page of subframes 4 or 5 that is assigned to normally contain the almanac data of that SV" (NOTE: (a) this special meaning applies to the 25$^{th}$ pages of subframes 4 and 5 only, and (b) there may be data regarding another SV in the almanac-page referred to above as defined in paragraph 20.3.3.5.1.1). The health indication shall be given relative to the "as designed" capabilities of each SV (as designated by the configuration code -- see paragraph 20.3.3.5.1.6). Accordingly, any SV which does not have a certain capability will be indicated as "healthy" if the lack of this capability is inherent in its design or it has been configured into a mode which is normal from a user standpoint and does not require that capability.

Table 20-VII. NAV Data Health Indications

| BIT POSITION IN PAGE | | | INDICATION |
|---|---|---|---|
| 137 | 138 | 139 | |
| 0 | 0 | 0 | ALL DATA OK |
| 0 | 0 | 1 | PARITY FAILURE -- some or all parity bad |
| 0 | 1 | 0 | TLM/HOW FORMAT PROBLEM -- any departure from standard format (e.g., preamble misplaced and/or incorrect, etc.), except for incorrect Z-count, as reported in HOW |
| 0 | 1 | 1 | Z-COUNT IN HOW BAD -- any problem with Z-count value not reflecting actual code phase |
| 1 | 0 | 0 | SUBFRAMES 1, 2, 3 -- one or more elements in words three through ten of one or more subframes are bad. |
| 1 | 0 | 1 | SUBFRAMES 4, 5 -- one or more elements in words three through ten of one or more subframes are bad. |
| 1 | 1 | 0 | ALL UPLOADED DATA BAD -- one or more elements in words three through ten of any one (or more) subframes are bad. |
| 1 | 1 | 1 | ALL DATA BAD -- TLM word and/or HOW and one or more elements in any one (or more) subframes are bad. |

## Table 20-VIII. Codes for Health of SV Signal Components

| MSB | | | | LSB | |
|---|---|---|---|---|---|
| 0 | 0 | 0 | 0 | 0 | → ALL SIGNALS OK |
| 0 | 0 | 0 | 0 | 1 | → ALL SIGNALS WEAK* |
| 0 | 0 | 0 | 1 | 0 | → ALL SIGNALS DEAD |
| 0 | 0 | 0 | 1 | 1 | → ALL SIGNALS HAVE NO DATA MODULATION |
| 0 | 0 | 1 | 0 | 0 | → $L_1$ P SIGNAL WEAK |
| 0 | 0 | 1 | 0 | 1 | → $L_1$ P SIGNAL DEAD |
| 0 | 0 | 1 | 1 | 0 | → $L_1$ P SIGNAL HAS NO DATA MODULATION |
| 0 | 0 | 1 | 1 | 1 | → $L_2$ P SIGNAL WEAK |
| 0 | 1 | 0 | 0 | 0 | → $L_2$ P SIGNAL DEAD |
| 0 | 1 | 0 | 0 | 1 | → $L_2$ P SIGNAL HAS NO DATA MODULATION |
| 0 | 1 | 0 | 1 | 0 | → $L_1$ C SIGNAL WEAK |
| 0 | 1 | 0 | 1 | 1 | → $L_1$ C SIGNAL DEAD |
| 0 | 1 | 1 | 0 | 0 | → $L_1$ C SIGNAL HAS NO DATA MODULATION |
| 0 | 1 | 1 | 0 | 1 | → $L_2$ C SIGNAL WEAK |
| 0 | 1 | 1 | 1 | 0 | → $L_2$ C SIGNAL DEAD |
| 0 | 1 | 1 | 1 | 1 | → $L_2$ C SIGNAL HAS NO DATA MODULATION |
| 1 | 0 | 0 | 0 | 0 | → $L_1$ & $L_2$ P SIGNAL WEAK |
| 1 | 0 | 0 | 0 | 1 | → $L_1$ & $L_2$ P SIGNAL DEAD |
| 1 | 0 | 0 | 1 | 0 | → $L_1$ & $L_2$ P SIGNAL HAS NO DATA MODULATION |
| 1 | 0 | 0 | 1 | 1 | → $L_1$ & $L_2$ C SIGNAL WEAK |
| 1 | 0 | 1 | 0 | 0 | → $L_1$ & $L_2$ C SIGNAL DEAD |
| 1 | 0 | 1 | 0 | 1 | → $L_1$ & $L_2$ C SIGNAL HAS NO DATA MODULATION |
| 1 | 0 | 1 | 1 | 0 | → $L_1$ SIGNAL WEAK* |
| 1 | 0 | 1 | 1 | 1 | → $L_1$ SIGNAL DEAD |
| 1 | 1 | 0 | 0 | 0 | → $L_1$ SIGNAL HAS NO DATA MODULATION |
| 1 | 1 | 0 | 0 | 1 | → $L_2$ SIGNAL WEAK* |
| 1 | 1 | 0 | 1 | 0 | → $L_2$ SIGNAL DEAD |
| 1 | 1 | 0 | 1 | 1 | → $L_2$ SIGNAL HAS NO DATA MODULATION |
| 1 | 1 | 1 | 0 | 0 | → SV IS TEMPORARILY OUT - do not use this SV during current pass** |
| 1 | 1 | 1 | 0 | 1 | → SV WILL BE TEMPORARILY OUT - use with caution** |
| 1 | 1 | 1 | 1 | 0 | → SPARE |
| 1 | 1 | 1 | 1 | 1 | → MORE THAN ONE COMBINATION WOULD BE REQUIRED TO DESCRIBE ANOMALIES (EXCEPT THOSE MARKED BY **) |

* 3 TO 6 dB BELOW SPECIFIED POWER LEVEL DUE TO REDUCED POWER OUTPUT, EXCESS PHASE NOISE, SV ATTITUDE, ETC.

Additional SV health data are given in subframe 1. The data given in subframes 1, 4, and 5 of the other SVs may differ from that shown in subframes 4 and/or 5 since the latter may be updated at a different time.

The eight-bit health status words shall occupy bits 17 through 24 of word five in those 32 pages which contain almanac data for individual SVs. the six-bit health status words shall occupy the 24 MSBs of words four through nine in page 25 of subframe 5 plus bits 19 through 24 of word 8, the 24 MSBs of word 9, and the 18 MSBs of word 10 in page 25 of subframe 4.

The eight-bit health status words shall occupy bits 17 through 24 of word five in those 32 pages which contain almanac data for individual SVs. The six-bit health status words shall occupy the 24 MSBs of words four through nine in page 25 of subframe 5 plus bits 19 through 24 of word 8, the 24 MSBs of word 9, and the 18 MSBs of word 10 in page 25 of subframe 4.

20.3.3.5.1.4 (Reserved).

20.3.3.5.1.5 (Reserved).

20.3.3.5.1.6 Anti-Spoof (A-S) Flags and SV Configurations. Page 25 of subframe 4 shall contain a four-bit-long term for each of up to 32 SVs to indicate the A-S status and the configuration code of each SV. The MSB of each four-bit term shall be the A-S flag with a "1" indicating that A-S is ON. The three LSBs shall indicate the configuration of each SV using the following code:

| Code | SV Configuration |
|---|---|
| 000 | "Block I" SV |
| 001 | "Block II" SV (capability for: A-S, plus flags for A-S and "alert" in the HOW; has memory capacity for 14 days of uploaded NAV data). |

Additional codes will be assigned in the future, should the need arise.

These four-bit terms shall occupy bits 9 through 24 of word three, the 24 MSBs of words four through seven, and the 16 MSBs of word eight, all in page 25 of subframe 4.

20.3.3.5.1.7 Almanac Reference Week. Bits 17 through 24 of word three in page 25 of subframe 5 shall indicate the number of the week ($WN_a$) to which the almanac reference time ($t_{oa}$) is referenced (see paragraphs 20.3.3.5.1.2 and 20.3.3.5.2.2). The $WN_a$ term consists of the eight LSBs of the full week number. Bits 9 through 16 of word three in page 25 of subframe 5 shall contain the value of $t_{oa}$ which is referenced to this $WN_a$.

20.3.3.5.1.8 Universal Coordinated Time (UTC) Parameters. The 24 MSBs of words six through nine plus the eight MSBs of word ten in page 18 of subframe 4 shall contain the parameters related to correlating UTC time with GPS time. The bit length, scale factors, ranges, and units of these parameters are given in Table 20-IX. The related algorithms are described in paragraph 20.3.3.5.2.4. These UTC parameters shall be updated at least once every 6 days.

20.3.3.5.1.9 Ionospheric Data. The ionospheric parameters which allow the "$L_1$ only" or "$L_2$ only" user to utilize the ionospheric model (reference paragraph 20.3.3.5.2.5) for computation of the ionospheric delay are contained in page 18 of subframe 4. They occupy bits 9 through 24 of word three plus the 24 MSBs of words four and five. The bit lengths, scale factors, ranges, and units of these parameters are given in Table 20-X. These parameters shall be updated at least once every 6 days.

Table 20-IX. UTC Parameters

| Parameter | No. of Bits** | Scale Factor (LSB) | Effective Range*** | Units |
|---|---|---|---|---|
| $A_0$ | 32 * | $2^{-30}$ | | seconds |
| $A_1$ | 24 * | $2^{-50}$ | | sec/sec |
| $\Delta t_{LS}$ | 8 * | 1 | | seconds |
| $t_{ot}$ | 8 | $2^{12}$ | 602,112 | seconds |
| $WN_t$ | 8 | 1 | | weeks |
| $WN_{LSF}$ | 8 | 1 | | weeks |
| DN | 8**** | 1 | 7 | days |
| $\Delta t_{LSF}$ | 8 * | 1 | | seconds |

* Parameters so indicated shall be two's complement, with the sign bit (+ or -) occupying the MSB;

** See Figure 20-1 for complete bit allocation in subframe;

*** Unless otherwise indicated in this column, effective range is the maximum range attainable with indicated bit allocation and scale factor.

**** Right justified.

Table 20-X. Ionospheric Parameters

| Parameter | No. of Bits** | Scale Factor (LSB) | Effective Range*** | Units |
|---|---|---|---|---|
| $\alpha_0$ | 8 * | $2^{-30}$ | | seconds |
| $\alpha_1$ | 8 * | $2^{-27}$ | | sec. per semicircle |
| $\alpha_2$ | 8 * | $2^{-24}$ | | sec. per semicircle$^2$ |
| $\alpha_3$ | 8 * | $2^{-24}$ | | sec. per semicircle$^3$ |
| $\beta_0$ | 8 * | $2^{11}$ | | seconds |
| $\beta_1$ | 8 * | $2^{14}$ | | sec. per semicircle |
| $\beta_2$ | 8 * | $2^{16}$ | | sec. per semicircle$^2$ |
| $\beta_3$ | 8 * | $2^{16}$ | | sec. per semicircle$^3$ |

* Parameters so indicated shall be two's complement, with the sign bit (+ or -) occupying the MSB;

** See Figure 20-1 for complete bit allocation in subframe;

*** Unless otherwise indicated in this column, effective range is the maximum range attainable with indicated bit allocation and scale factor.

20.3.3.5.1.10 Special Messages. Page 17 of subframe 4 shall be reserved for special messages with the specific contents at the discretion of the Operating Command. It shall accommodate the transmission of 22 eight-bit ASCII characters. The requisite 176 bits shall occupy bits 9 through 24 of word three, the 24 MSBs of words four through nine, plus the 16 MSBs of word ten. The eight MSBs of word three shall contain the data ID and SV ID, while bits 17 through 22 of word ten shall be spares containing alternating ones and zeros. The remaining 50 bits of words three through ten are used for parity (six bits/word) and parity computation (two bits in word ten). The eight-bit ASCII characters shall be limited to the following set:

| Alphanumeric Character | ASCII Character | Code (Octal) |
|---|---|---|
| A - Z | A - Z | 101 - 132 |
| 0 - 9 | 0 - 9 | 060 - 071 |
| + | + | 053 |
| - | - | 055 |
| . (Decimal point) | . | 056 |
| ' (Minute mark) | ' | 047 |
| ° (Degree sign) | ° | 370 |
| / | / | 057 |
| Blank | Space | 040 |
| : | : | 072 |
| " (Second mark) | " | 042 |

20.3.3.5.1.11 Spare Data Fields. All bits of words three through ten, except the 58 bits used for data ID, SV (page) ID, parity (six LSBs of each word) and parity computation (bits 23 and 24 of word ten) of pages 13, 14 and 15 of subframe 4, and those almanac pages assigned SV ID of zero are designated as spares. In addition, as shown in Table 20-XI, several smaller groups of spare bits exist in subframes 4 and 5. These spare bit positions of each word shall contain a pattern of alternating ones and zeroes with valid word parity.

20.3.3.5.1.12 (Reserved).

20.3.3.5.2 Algorithms Related to Subframe 4 and 5 Data. The following algorithms shall apply when interpreting Almanac, Universal Coordinated Time, and Ionospheric data in the Navigation Message.

20.3.3.5.2.1 Almanac. The almanac is a subset of the clock and ephemeris data, with reduced precision. The user algorithm is essentially the same as the user algorithm used for computing the precise ephemeris from the subframe 1, 2, and 3 parameters (see Table 20-IV). The almanac content for one SV is given in Table 20-VI. A close inspection of Table 20-VI will reveal that a nominal inclination angle of 0.30 semicircles is implicit and that the parameter $\delta_i$ (correction to inclination) is transmitted, as opposed to the value being computed by the user. All other parameters appearing in the equations of Table 20-IV, but not included in the content of the almanac, are set to zero for SV position determination. In these respects, the application of the Table 20-IV equations differs between the almanac and the ephemeris computations.

Table 20-XI. Spare Bits in Subframes 4 and 5

| Subframe | Page(s) | Word(s) | Spare Bit Positions in Word(s) |
|---|---|---|---|
| 4 | 12, 19, 20, 22, 23, 24 | 9 | 9 - 24 |
| 4 | 1, 6, 11, 12, 16, 19, 20, 21, 22, 23, 24 | 10 | 1 - 22 |
| 4 | 17 | 10 | 17 - 22 |
| 4 | 18 | 10 | 9 - 22 |
| 4 | 25 | 8 | 17 - 18 |
| 4 | 25 | 10 | 19 - 22 |
| 5 | 25 | 10 | 1 - 22 |

NOTE: In addition, all bits of words three through ten in pages 13, 14, and 15 of subframe 4 (except the 58 bits used for data ID, SV (page) ID, parity and parity computation) are also designated as spares.

The user is cautioned that the sensitivity to small perturbations in the parameters is even greater for the almanac than for the ephemeris, with the sensitivity of the angular rate terms over the interval of applicability on the order of $10^{14}$ meters/(semicircle/second). An indication of the URE provided by a given almanac as a function of time, relative to the first valid transmission time (age of data, almanac — AODA), is as follows:

| AODA | Almanac Ephemeris URE (estimated by analysis) $1\sigma$ (Meters) |
|---|---|
| 1 day | 900* |
| 1 week | 1,200* |
| 2 weeks | 3,600* |

* Larger errors may be encountered during eclipse seasons and whenever a propulsive event has occurred.

The time past first valid transmission time (AODA) may be computed nominally as

$$AODA = t_k + 302{,}400 \text{ seconds},$$

where the computation of $t_k$ is described in paragraph 20.3.3.5.2.2.

20.3.3.5.2.2 Almanac Reference Time. The almanac reference time, $t_{oa}$, is nominally the multiple of $2^{12}$ seconds truncated from 3.5 days after the first valid transmission time for this almanac data set (reference paragraph 20.3.4.5). The almanac shall be renewed each six days as a minimum. Therefore, the almanac reference time is not ambiguous during the transmission period. GPS time, t, shall differ from $t_{oa}$ by less than 3.5 days during the transmission period. The time from epoch $t_k$ (see Table 20-IV) shall be computed as described in Table 20-IV, except that $t_{oe}$ shall be replaced with $t_{oa}$.

However, if the user wishes to extend the use time of the almanac beyond the time span that it is being transmitted, he must account for crossovers into time spans where these computations of $t_k$ are not valid. This may be accomplished without time ambiguity by recognizing that the almanac reference time ($t_{oa}$) is referenced to the almanac reference week ($WN_a$) both of which are given in word three of page 25 of subframe 5 (see paragraph 20.3.3.5.1.7). The CS shall ensure that all $t_{oa}$ values in subframes 4 and 5 are the same for a given almanac data set and that they differ for successive data sets which contain changes in almanac parameters or SV health. Note that cutover to a new upload may occur between the almanac pages of interest and page 25 of subframe 5 (reference paragraph 20.3.4.1), and thus there may be a temporary inconsistency between $t_{oa}$, in the almanac page of interest, and in word 3 of page 25 of subframe 5. The $t_{oa}$ mismatch signifies that this $WN_a$ may not apply to the almanac of interest and that the user must not apply almanac data beyond its period of transmission until he obtains these pages with identical values of $t_{oa}$.

20.3.3.5.2.3 Almanac Time Parameters. The almanac time parameters shall consist of an 11-bit constant term ($a_{f0}$) and an 11-bit first order term ($a_{f1}$). The applicable first order polynomial, which shall provide time to within 2 microseconds of GPS time (t) during the interval of applicability, is given by

$$t = t_{sv} - \Delta t_{sv}$$

where

$t$ = GPS system time (seconds),

$t_{sv}$ = effective SV PRN code phase time at message transmission time (seconds),

$\Delta t_{sv}$ = SV PRN code phase time offset (seconds).

The SV PRN code phase offset is given by

$$\Delta t_{sv} = a_{fo} + a_{f1}\, t_k$$

where the computation of $t_k$ is described in paragraph 20.3.3.5.2.2, and the polynomial coefficients $a_{fo}$ and $a_{f1}$ are given in the almanac. Since the periodic relativistic effect is less than 25 meters, it need not be included in time scale used for almanac evaluation. Over the span of applicability, it is expected that the almanac time parameters will provide a statistical URE component of less than 135 meters, one sigma. This is partially due to the fact that the error caused by the truncation of $a_{fo}$ and $a_{f1}$, may be as large as 150 meters plus 50 meters/day relative to the $t_{oa}$ reference time.

20.3.3.5.2.4 Universal Coordinated Time (UTC). Page 18 of subframe 4 includes (1) the parameters needed to relate GPS time to UTC and (2) notice to the user regarding the scheduled future or recent past (relative to NAV message upload) value of the delta time due to leap seconds ($\Delta t_{LSF}$), together with the week number ($WN_{LSF}$) and the day number (DN) at the end of which the leap second becomes effective. "Day one" is the first day relative to the end/start of week and the $WN_{LSF}$ value consists of the eight LSBs of the full week number. The user must account for the truncated nature of this parameter as well as truncation of WN, $WN_t$ and $W_{LSF}$ due to rollover of the full week number (see paragraph 3.3.4(b)). The CS shall manage these parameters such that the absolute value of the difference between the untruncated WN and $WN_{LSF}$ values shall not exceed 127.

Depending upon the relationship of the effectivity date to the user's current GPS time, the following three different UTC/GPS-time relationships exist:

a. Whenever the effectivity time indicated by the $WN_{LSF}$ and the DN values is not in the past (relative to the user's present time), and the user's present time does not fall in the timespan which starts at DN + 3/4 and ends at DN + 5/4, the UTC/GPS-time relationship is given by

$$t_{UTC} = (t_E - \Delta t_{UTC}) \text{ [Modulo 86400 seconds]}$$

where $t_{UTC}$ is in seconds and

$$\Delta t_{UTC} = \Delta t_{LS} + A_o + A_1 (t_E - t_{ot} + 604800 (WN - WN_t)), \text{ seconds;}$$

$t_E$ = GPS time as estimated by the user on the basis of correcting $t_{SV}$ for factors described in paragraph 20.3.3.3.3 as well as for ionospheric and SA (dither) effects;

$\Delta t_{LS}$ = delta time due to leap seconds;

$A_o$ and $A_1$ = constant and first order terms of polynomial;

$t_{ot}$ = reference time for UTC data (reference 20.3.4.5);

WN = current week number (derived from subframe 1);

$WN_t$ = UTC reference week number.

The estimated GPS time ($t_E$) shall be in seconds relative to end/start of week. The reference time for UTC data ($t_{ot}$) shall be referenced to the start of that week whose number ($WN_t$) is given in word eight of page 18 in subframe 4. The $WN_t$ value consists of the eight LSBs of the full week number. The user must account for the truncated nature of this parameter as well as truncation of WN, $WN_t$ and $W_{LSF}$ due to rollover of the full week number (see paragraph 3.3.4(b)). The CS shall manage these parameters such to that the absolute value of the difference between the untruncated WN and $WN_t$ values shall not exceed 127.

b. Whenever the user's current time falls within the timespan of DN + 3/4 to DN + 5/4, proper accommodation of the leap second event with a possible week number transition is provided by the following expression for UTC:

$$t_{UTC} = W[\text{Modulo } (86400 + \Delta t_{LSF} - \Delta t_{LS})], \text{ seconds;}$$

where

$$W = (t_E - \Delta t_{UTC} - 43200)[\text{Modulo } 86400] + 43200, \text{ seconds;}$$

and the definition of $\Delta t_{UTC}$ (as given in "a" above) applies throughout the transition period. Note that when a leap second is added, unconventional time values of the form 23: 59: 60.xxx are encountered. Some user equipment may be designed to approximate UTC by decrementing the running count of time within several seconds after the event, thereby promptly returning to a proper time indication. Whenever a leap second event is encountered, the user equipment must consistently implement carries or borrows into any year/week/day counts.

c. Whenever the effectivity time of the leap second event, as indicated by the $WN_{LSF}$ and DN values, is in the "past" (relative to the user's current time), the relationship previously given for $t_{UTC}$ in "a" above is valid except that the value of $\Delta t_{LSF}$ is substituted for $\Delta t_{LS}$. The CS will coordinate the update of UTC parameters at a future upload so as to maintain a proper continuity of the $t_{UTC}$ time scale.

20.3.3.5.2.5 Ionospheric Model. The "two frequency" ($L_1$ and $L_2$) user shall correct the time received from the SV for ionospheric effect by utilizing the time delay differential between $L_1$ and $L_2$ (reference paragraph 20.3.3.3.3.3). The "one frequency" user, however, may use the model given in Figure 20-6 to make this correction. The "one frequency" user, however, may use the model given in Figure 20-6 to make this correction. It is estimated that the use of this model will provide at least a 50 percent reduction in the single - frequency user's RMS error due to ionospheric propagation effects.

The ionospheric correction model is given by

$$T_{iono} = \begin{cases} F * \left[5.0 * 10^{-9} + (AMP)\left(1 - \frac{x^2}{2} + \frac{x^4}{24}\right)\right] & , |x| < 1.57 \\ F * (5.0 * 10^{-9}) & , |x| \geq 1.57 \end{cases} \text{(sec)}$$

where

$T_{iono}$ is referred to the L1 frequency; if the user is operating on the L2 frequency, the correction term must be multiplied by $\gamma$ (reference paragraph 20.3.3.3.3.2),

$$AMP = \begin{cases} \sum_{n=0}^{3} \alpha_n \phi_m^n, \ AMP \geq 0 \\ \text{if } AMP < 0, \ AMP = 0 \end{cases} \text{(sec)}$$

$$x = \frac{2\pi(t - 50400)}{PER}, \text{ (radians)}$$

$$PER = \begin{cases} \sum_{n=0}^{3} \beta_n \phi_m^n, \ PER \geq 72{,}000 \\ \text{if } PER < 72{,}000, \ PER = 72{,}000 \end{cases} \text{(sec)}$$

$F = 1.0 + 16.0\,[0.53 - E]^3$, and

$\alpha_n$ and $\beta_n$ are the satellite transmitted data words with n = 0, 1, 2, and 3.

Other equations that must be solved are

$$\phi_m = \phi_i + 0.064 \cos(\lambda_i - 1.617) \text{ (semi-circles)},$$

$$\lambda_i = \lambda_u + \frac{\psi \sin A}{\cos \phi_i} \text{ (semi-circles)},$$

$$\phi_i = \begin{cases} \phi_u + \psi \cos A \text{ (semi-circles)}, \ |\phi_i| \leq 0.416 \\ \text{if } \phi_i > 0.416, \text{ then } \phi_i = +0.416 \\ \text{if } \phi_i < -0.416, \text{ then } \phi_i = -0.416 \end{cases} \text{(semi-circles)},$$

$$\psi = \frac{0.0137}{E + 0.11} - 0.022 \text{ (semi-circles)},$$

$$t = 4.32 * 10^4 \lambda_i + \text{GPS time (sec)}$$

where

$0 \leq t < 86400$, therefore: if $t \geq 86400$ seconds, subtract 86400 seconds; if $t < 0$ seconds, add 86400 seconds.

Figure 20-6. Ionospheric Model (Sheet 1 of 2)

The terms used in computation of ionospheric delay are as follows:

- Satellite Transmitted Terms

  $\alpha_n$ - the coefficients of a cubic equation representing the amplitude of the vertical delay (4 coefficients - 8 bits each)

  $\beta_n$ - the coefficients of a cubic equation representing the period of the model (4 coefficients - 8 bits each)

- Receiver Generated Terms

  E - elevation angle between the user and satellite (semi-circles)

  A - azimuth angle between the user and satellite, measured clockwise positive from the true North (semi-circles)

  $\Phi_u$ - user geodetic latitude (semi-circles) WGS-84

  $\lambda_u$ - user geodetic longitude (semi-circles) WGS-84

  GPS time - receiver computed system time

- Computed Terms

  X - phase (radians)

  F - obliquity factor (dimensionless)

  t - local time (sec)

  $\Phi_m$ - geomagnetic latitude of the earth projection of the ionospheric intersection point (mean ionospheric height assumed 350 km) (semicircles)

  $\lambda_i$ - geodetic longitude of the earth projection of the ionospheric intersection point (semicircles)

  $\Phi_i$ - geodetic latitude of the earth projection of the ionospheric intersection point (semicircles)

  $\Psi$ - earth's central angle between user position and earth projection of ionospheric intersection point (semi-circles)

Figure 20-6. Ionospheric Model (Sheet 2 of 2)

20.3.3.5.2.6 (Reserved).

20.3.4 Timing Relationships. The following conventions shall apply.

20.3.4.1 Paging and Cutovers. At end/start of week (a) the cyclic paging of subframes 1 through 5 shall restart with subframe 1 regardless of which subframe was last transmitted prior to end/start of week, and (b) the cycling of the 25 pages of subframes 4 and 5 shall restart with page 1 of each of these subframes, regardless of which page was the last to be transmitted prior to the end/start of week. It shall be a CS responsibility to ensure that all upload and page cutovers shall occur on frame boundaries (i.e., Modulo 30 seconds relative to end/start of week); accordingly, new data in subframes 4 and 5 may start to be transmitted with any of the 25 pages of these subframes.

20.3.4.2 SV Time vs. GPS Time. In controlling the SVs and uploading of data, the CS shall allow for the following timing relationships:

a. Each SV operates on its own SV time;

b. All time-related data in the TLM word and the HOW shall be in SV-time;

c. All other data in the NAV message shall be relative to GPS time;

d. The acts of transmitting the NAV message, shall be executed by the SV on SV time.

20.3.4.3 Speed of Light. The speed of light used by the CS for generating the data described in the above paragraphs is

$$c = 2.99792458 \times 10^8 \text{ meters per second}$$

which is the official WGS-84 speed of light. The user shall use the same value for the speed of light in his computations.

20.3.4.4 Data Sets. The CS shall ensure that the 8 LSBs of the IODC value in subframe 1 shall be equal to the IODE values in subframes 2 and 3 and that the full IODC number will be different from any value transmitted by the SV during the preceding 7 day interval. The CS shall also ensure that the IODE value transmitted will be different from any IODE value transmitted by that SV during the preceding 6 hour interval. The CS shall upload the data of subframes 1, 2 and 3 in data sets covering a 14-day span. The sets for the first approximately one-day period (see below) following an upload shall be transmitted by the SV for periods of one hour each. An exception to this is that the first one-hour set can be cut-in (reference paragraph 20.3.4.1) at any time during the hour (including the one-hour epoch) and therefore may be transmitted by the SV for less than one hour. Subsequent one-hour sets shall have cutovers exclusively on one-hour epochs, relative to end/start of week. The data sets of the second through fourteenth days shall be transmitted by the SV for four hours each. Cutover to four-hour data sets from one-hour sets and subsequent cutovers to succeeding four-hour data sets shall always occur Modulo four hours relative to end/start of week.

The CS shall upload sufficient one-hour data sets to ensure (a) that the SV will transmit one-hour data sets for a minimum period of 24 hours, and (b) that the SV will transmit additional one-hour data sets as needed to properly accommodate upload scheduling margins and the four-hour cutover timing relative to end/start of week, as specified above. The maximum number of one-hour data sets shall be 29.

20.3.4.5 Reference Times. Many of the parameters which describe the SV state vary with true time, and must therefore be expressed as time functions with coefficients provided by the Navigation Message so as to be evaluatable by the user equipment. These include the following parameters as functions of GPS time:

a. SV time,
b. Mean anomaly,
c. Longitude of ascending node,
d. UTC,
e. Inclination.

Each of these parameters is formulated as a polynomial in time. The specific time scale of expansion can be arbitrary. Due to the short data field lengths available in the Navigation Message format, the nominal epoch of the polynomial is chosen near the midpoint of the expansion range so that quantization error is small. This results in time epoch values which can be different for each data set. Time epochs contained in the Navigation Message and the algorithms which utlize them are related as follows:

| Epoch | Application Algorithm Reference |
|---|---|
| $t_{oc}$ | 20.3.3.3.3.1 |
| $t_{oe}$ | 20.3.3.4.3 |
| $t_{oa}$ | 20.3.3.5.2.2 and 20.3.3.5.2.3 |
| $t_{ot}$ | 20.3.3.5.2.4 |

The following describes the nominal selection, which will be expressed Modulo 604,800 seconds in the Navigation Message text:

$t_{oc}$ ≈ 2 hours after the first valid transmission time for four-hour fit interval data sets, and 3 hours after the start of transmission for six-hour fit interval data sets.

$t_{oe}$ ≈ 2 hours after the first valid transmission time for four-hour fit interval data sets, and 3 hours after the start of transmission for six-hour fit interval data sets.

$t_{oa}$ ≈ 3.5 days after the first valid transmission time.

$t_{ot}$ ≈ 3.5 days after the first valid transmission time.

The coefficients of expansion are obviously dependent upon the choice of epoch, and thus the epoch time and expansion coefficients must be treated as an inseparable parameter set. Note that a user applying current navigation data will normally be working with negative values of $(t-t_{oc})$ and $(t-t_{oe})$ in evaluating the expansions.

The CS will introduce small deviations from the nominal if necessary to preclude possible data set transition ambiguity when a new upload is cut over for transmission. A change of reference time is used to indicate a change of values in the data set.

20.3.5 Data Frame Parity. The data signal shall contain parity coding according to the following conventions.

20.3.5.1 SV/CS Parity Algorithm. This algorithm links 30-bit words within and across subframes of ten words, using the (32.26) Hamming Code described in Table 20-XII.

20.3.5.2 User Parity Algorithm. As far as the user is concerned, several options are available for performing data decoding and error detection. Figure 20-7 presents an example flow chart that defines one way of recovering data ($d_n$) and checking parity. The parity bit $D_{30}^*$ is used for recovering raw data. The parity bits $D_{29}^*$ and $D_{30}^*$, along with the recovered raw data ($d_n$) are modulo-2 added in accordance with the equations appearing in Table 20-XII for $D_{25}$ . . . $D_{30}$, which provide computed parity to compare with transmitted parity $D_{25}$ . . . $D_{30}$.

Table 20-XII. Parity Encoding Equations

$D_1 = d_1 \oplus D_{30}^*$

$D_2 = d_2 \oplus D_{30}^*$

$D_3 = d_3 \oplus D_{30}^*$

$\bullet \quad \bullet$

$\bullet \quad \bullet$

$\bullet \quad \bullet$

$\bullet \quad \bullet$

$D_{24} = d_{24} \oplus D_{30}^*$

$D_{25} = D_{29}^* \oplus d_1 \oplus d_2 \oplus d_3 \oplus d_5 \oplus d_6 \oplus d_{10} \oplus d_{11} \oplus d_{12} \oplus d_{13} \oplus d_{14} \oplus d_{17} \oplus d_{18} \oplus d_{20} \oplus d_{23}$

$D_{26} = D_{30}^* \oplus d_2 \oplus d_3 \oplus d_4 \oplus d_6 \oplus d_7 \oplus d_{11} \oplus d_{12} \oplus d_{13} \oplus d_{14} \oplus d_{15} \oplus d_{18} \oplus d_{19} \oplus d_{21} \oplus d_{24}$

$D_{27} = D_{29}^* \oplus d_1 \oplus d_3 \oplus d_4 \oplus d_5 \oplus d_7 \oplus d_8 \oplus d_{12} \oplus d_{13} \oplus d_{14} \oplus d_{15} \oplus d_{16} \oplus d_{19} \oplus d_{20} \oplus d_{22}$

$D_{28} = D_{30}^* \oplus d_2 \oplus d_4 \oplus d_5 \oplus d_6 \oplus d_8 \oplus d_9 \oplus d_{13} \oplus d_{14} \oplus d_{15} \oplus d_{16} \oplus d_{17} \oplus d_{20} \oplus d_{21} \oplus d_{23}$

$D_{29} = D_{30}^* \oplus d_1 \oplus d_3 \oplus d_5 \oplus d_6 \oplus d_7 \oplus d_9 \oplus d_{10} \oplus d_{14} \oplus d_{15} \oplus d_{16} \oplus d_{17} \oplus d_{18} \oplus d_{21} \oplus d_{22} \oplus d_{24}$

$D_{30} = D_{29}^* \oplus d_3 \oplus d_5 \oplus d_6 \oplus d_8 \oplus d_9 \oplus d_{10} \oplus d_{11} \oplus d_{13} \oplus d_{15} \oplus d_{19} \oplus d_{22} \oplus d_{23} \oplus d_{24}$

where

$d_1, d_2, \ldots, d_{24}$ are the source data bits,

the symbol (*) is used to identify the last 2 bits of the previous word of the subframe,

$D_{25}, \ldots, D_{30}$ are the computed parity bits,

$D_1, D_2, D_3, \ldots D_{29}, D_{30}$ are the bits transmitted by the SV, and

$\oplus$ is the "Modulo-2" or "Exclusive-Or" operation.

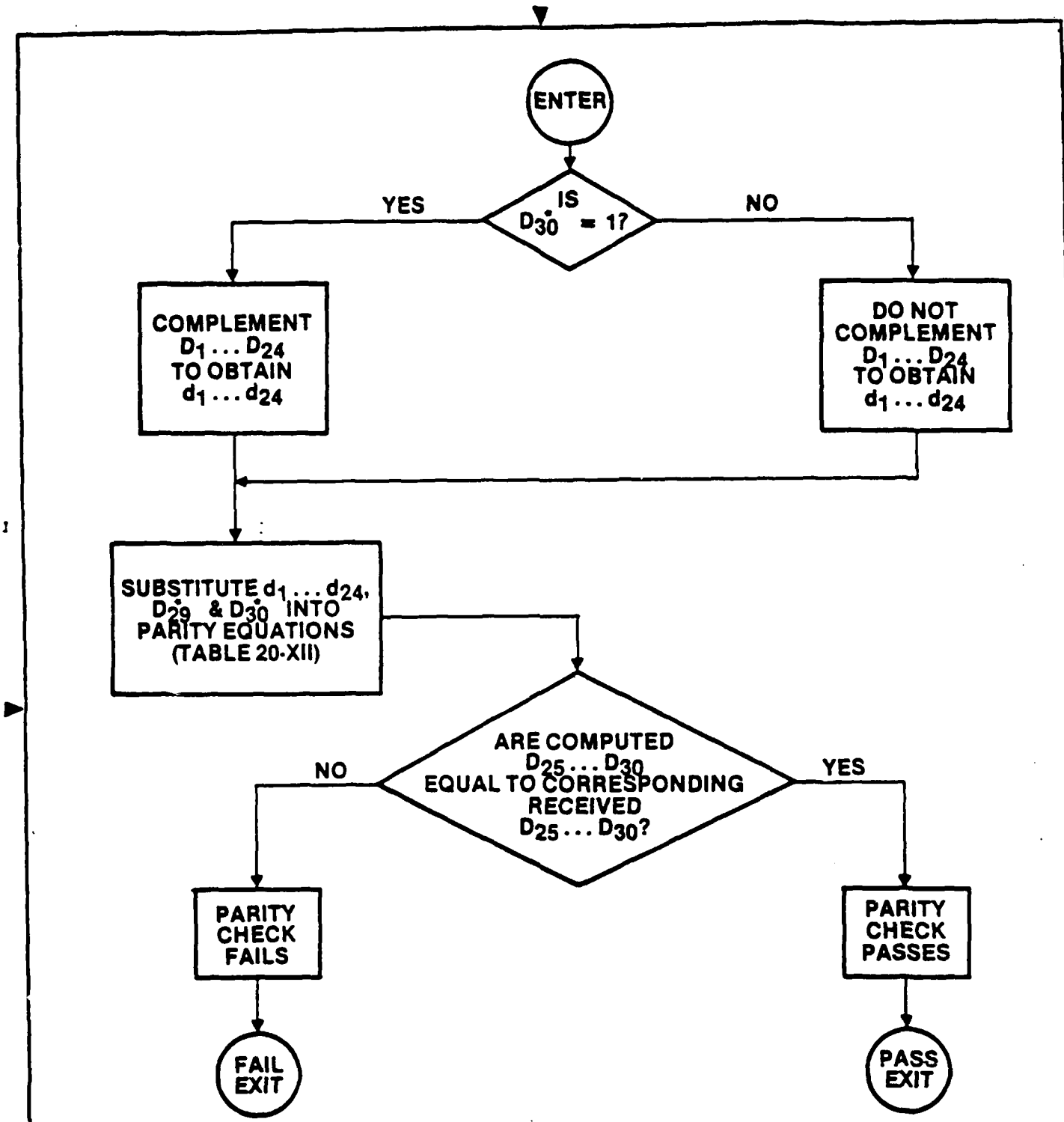


Figure 20-7. Example Flow Chart for User Implementation of Parity Algorithm

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